Journal of Environmental Sciences Studies

Journal home page: www.jess.ir

Mapping and Assessing the Precipitation and Temperature Changes in Arasbaran Forest Ecosystem under Climate Change, NW of Iran

Roya Abedi[a*], Ladan Kazemi Rad[b,]

[*]a . Assistant professor, Department of forestry, Ahar faculty of agriculture and natural resources, University of Tabriz
b . Environmental Research Institute, Academic Center for Education, Culture & Research, Iran

[*]Email Address : royaabedi@tabrizu.ac.ir

Received: (April - 7-2020)
Accepted: (May - 5 -2020)

Abstract

This study was conducted to perform the most parameters of weather data for current and future climate in the Arasbaran forest area including precipitation and temperature. The base climate data contained daily precipitation, minimum temperatures, and maximum temperatures parameters of four weather stations. The LARS-WG was used to simulation based on the historical climate data from 2000 to 2017 and data generating for future climate forecasting was evaluate for 2018-2030. Then, the model was evaluated after assessing the model ability in each station for all four stations by comparing the monthly means and variances of observed and generated data in all stations. From the results, the study found that the precipitation level would increase in the study area. In the case of minimum and maximum temperatures, the minimum temperature would decrease 0.2-0.3 °C in Jolfa station and will increase 0.1-0.2 °C in Tabriz and 4.5-4.6 °C in Kaleybar stations. In addition, the maximum temperature would increase 0.1-0.2 °C at both in the study area. The distribution map of climatic parameters in the past and future showed that the high precipitation patterns of rain forecasting maps will be eliminated and increasing the minimum and maximum temperature and amount of radiation certified that the occurrence of global warming in this forest region will be inevitable.

Keywords:
Arasbaran Forest; Climate, LARS-WG; Mapping; Simulation

1. Introduction

Forest ecosystems are one of the important terrestrial natural resource and a crucial component of the global cycle for economic productivity utilization of nature; wildlife, water, and soil conservation, maintaining biodiversity, providing ecosystem service and hold large stores of carbon (Wan et al. 2017; Xiao-Ying et al. 2013). Forest ecosystems could increase soil stabilization, decline impacts of flooding by drinking water supplies so that flood frequency strongly correlated with the percent of remaining forest, dense forest canopies result in higher humidity levels and the understory can buffer drought effects. In forests, shading by over-story trees can mediate warming temperature for understory species. Nevertheless, global climate change treats these functions of forest ecosystems (Espeland and Kettenring 2018). There is evidence that showed an increase in temperature, a reduction in the amount of snow and ice, rising sea levels, and greenhouse gas concentrations in the mid-twenties century. These changes can significantly affect natural and human systems. The forest ecosystems current and future productivity directly correlated with the climate changes both positively and negatively (Moreno et al. 2018; Pirovani et al. 2018) and forests will be greatly affected by climate change include increased occurrence of forest fires, pests, and disease, loss of thousands of species and accelerate the anthropogenic greenhouses gas emissions. Therefore, reduction of forest area will decrease biodiversity, water and carbon and climate regulation and also caused the elimination of many cultural and spiritual benefits of forests (Brecka et al., 2018; Lasco et al. 2008).The role of forests is an integral part of the climate change challenge and the global carbon cycle. Deforestation and forest degradation are significant contributors to global greenhouse gas emissions (Keenan 2008). Changing in climate are affecting the forest and its ability to deliver its environmental services. To enhance the mitigation role of the forest and at the same time increase their resilience to climate change, science-based policies and programs must put in place (Lasco et al. 2008). Climate change is the world’s most challenge that will require a wide variety of proposed ways to adapt (Fischer 2019). Therefore, there is an urgent need for scientific studies to quantify the amount of these effects on natural ecosystems especially forest ecosystems (Espeland and Kettenring

2018). Most of the researches on forests and climate change focused on the role of forest ecosystems on carbon sequestration and climate change mitigation (Lasco et al. 2018). Recent researches have focused on new approaches to assessing the amount of climate change of forest ecosystems. Climate change models have been used for the dedication of climate condition change and evaluate the risk assessment of that in natural ecosystems that approaches can provide a guide to predict to which future climate conditions happen.These models have performed in an alternative approach afterward (Keenan 2016). The qualitative modeling approach will be applied in the next useful identifying research priorities for modeling complex ecosystems,even under uncertain system understanding or deficiencies in quantitative data (Herr et al. 2016). Previous studies illustrate that protect forest land use could increase the amount of carbon storage, total carbon in biomass, carbon sequestration rate and total carbon sequestration. There are three ways to employ in forest management plans to curb the rate of Co2 increase in the atmosphere (Lasco et al. 2007).The relationship between climate and forest dynamics has been studied extensively across a large scale (Moreno et al. 2018). Numerous researchers have documented the climate change on forest ecosystems and studied the processes in forest ecosystems in recent decades (Wan et al. 2017; Booth 2011; Klapwijk et al. 2018; Lagergren F, Jonsson 2017; Ovando and Caparros 2009). As well as, Zarghami et al. (2011) predicted the climate change based on the LARS-WG model as a successful downscaling tool in East-Azarbayjan province in Iran. They reported that the discover changes shift the climate of the province from semi-arid to arid based on the De Martonne aridity index. Xiao-Ying et al. (2013) reviewed the researches on climate change impacts on the forest ecosystems in northeast China and resulted that the growing season of coniferous trees has been increasing at an average rate of 3.9 days per decade. In addition, the occurrence cycles of pests and diseases have shortened and their distribution ranges have expanded. Goodarzi et al. (2014) evaluated two downscale models for the purpose of runoff simulation in an arid climate in Iran. They illustrate that the prediction method could figure the risk of flood and damage in the future. Ding et al. (2016) perform valuing climate change in the European forest ecosystem. Moreno and Hasenauer (2016) produced a downscaling model approach for precipitation, minimum and maximum temperatures to fulfill the need for climate datasets with a high spatial and temporal resolution for Europe. Chisanga et al. (2017) used the LARS-WG model as a stochastic weather generator for simulating the precipitation and temperature at an agricultural research station under both current and future climate conditions. Based on the studies cited above, this study is clear quantitative research to plan the possible climate conditions and to identify the area that will be most affected in the future. Therefore, the purpose of this study was to express the quantify amount of scientific understanding the climate change in the Arasbaran forest ecosystem. Moreover, to identify the amount of change at the precipitation, minimum and maximum temperature in the future of the Arasbaran forest ecosystem in the northwest of Iran by the performance of the LARS-WG model in simulating and suitability of model application.

2. Materials and Methods

2.1. Study area

The Arasbaran forest constitutes an area of about 160,000 hectares in the north of East-Azarbayjan province in the northwest of Iran (38° 40´ and 39° 9´ latitude and 46° 42´ and 47° 3´ longitude).Arasbaran has distinct floristic, ecological, wildlife and cultural heritage characteristics that it has been announced to be a component biosphere resource because of its unique fauna and flora by UNESCO organization in 1976. The conditions of the region and the richness of fauna and flora have resulted in various landforms, vegetation types and climatic conditions.The climate of the Arasbaran region is humid and cold. The climatic diversity of this region is due to the main mountain directions that winds bring in humidity from the Caspian Sea in the east, the Mediterranean in the west and by Siberian low-pressure fronts from the north (Rasuly et al. 2010; Talebi et al. 2014)(Figure 1).

Figure 1. The geographic location of the study area

2.2. Weather data collection

The historical climate data used in this study was obtained from the Iran Meteorological Organization and General Office of Applied Meteorology Research Center of East Azarbayjan province. Data was contained daily precipitation (mm), daily minimum temperature (°C), and daily maximum temperature (°C) from four stations during the period 2000-2017. The location of synoptic stations was shown in Figure 1 and some additional details (containing latitude, longitude, and elevation) were given in Table 1 .

Table 1. The geographic position of synoptic stations

Stations	Latitude (°N)	Longitude (°E)	Elevation (m A.S.L)
Ahar	38° 26′	47° 04′	1390.5
Jolfa	38° 45′	45° 40′	736.2
Kaleybar	38° 52′	47° 01′	1180
Tabriz	38° 05′	46° 17′	1367.0

2.3. LARS-WG model analysis

LARS-WG model as a general circulation model was utilized In order to evaluate the climate change in the study area. 2.4. Description of LARS-WG Stochastic Weather Generator Long Ashton Research Weather Generator (LARS-WG) is one of the most popular stochastic weather generators, which can be used for the simulation of weather data at a single site under both current and future climate conditions (Farzanmanesh et al. 2012). A stochastic weather generator is a numerical model, which produces synthetic daily time series of climate variables, such as precipitation, and temperature (Rashidian 2017; Semenov and Brooks 1999).The LARS-WG (Download in www.iacr.bbsrc.ac.uk/mas-model/larswg.html) takes as input the long term daily information of the climatic parameters of interest for a site. This model can also generate the scenarios of changing the climate by perturbing the parameters derived from the observed data to generate synthetic data, representing future climate change (Zia Hashmi et al. 2011). It was developed for two main purposes:

- To provide a means of simulating synthetic weather time-series with statistical characteristics corresponding to the observed statistics at a site.
- To provide a mean of extending the simulation of weather time-series to unserved locations.Through the interpolation of the weather generator parameters obtain from running the model at neighboring sites (Semenov and Barrow 2002). Thus, A1B, A2, and B1 scenarios are applied during 2011-2030 and downscaled by using of the LARS-WG statistical model. A1B scenario indicates a future of balanced socio-economic and environmentally based development. A2 scenario assumes done in three steps:
- **Calibration:** that the current socioeconomic situation will continue. B1 scenario indicates that future development will be more environmentally based that at present (Zarghami et al. 2014).All of these steps were the 17 years observation data was split into two subsamples (Hassan et al. 2014; Tareghian and Rasmussen 2013) and 2000-2010 was used for model calibration.
- **Validation:** Comparison of the observed data (precipitation, Min and Max temperatures) with the LARS model generated meteorological data using statistical tests and comparative graphs. Validations are compared to those of observed data using t-test and f-test in order to gauge the ability of LARS-WG in reproducing the observed data statistics (Zia Hashmi et al. 2011). The second part of the data including 2010-2017 was used to model validation. The valid data then used to generate future climate (2018-2020).
- **Simulation for the future:** The prediction was performed based on A1, B2, and A1B scenarios and the output was derived from the future period (2018-2030).To evaluate the outputs of the model, observation and modeling data were compared to four parameters of minimum temperature, maximum temperature, precipitation and radiation using the t-student test and Pearson correlation. These tests used for comparing the synthetic data that are produced by the weather generator to the observed data in the baseline period (Zarghami et al 2011).

3. Results & Discussion

3.1. Assessment of modeling accuracy

The capability of the climate data model has direct effects on climate change assessment. Therefore, at first, the capability of this model was evaluated using the observed data of synoptic stations. This is done by comparing the statistical periodic monthly data generated by the model were performed using statistical methods and comparative diagrams. According to the results of this section of the study, the model performed a very well-fitting in monthly minimum and maximum temperatures to all months and all stations, but the model presents poorly in fitting performance in simulation the monthly precipitation. In general, the results showed that the LARS-WG model has the capability of modeling the climate of the stations under study based on a basic state scenario. Figures 2 to 5 were shown the comparison of modeled and observed values for the four parameters desired at synoptic stations. As can be seen, there is a perfect match and a little difference between standardized deviation and simulated data. The statistical analysis of the modeling results with observation values showed that there was not a significant difference between the two data sets at the 95% level. Also, Pearson correlation values between these two series of data were acceptable results at the 99% level. The distribution map of climate parameters was obtained by interpolation in GIS software.

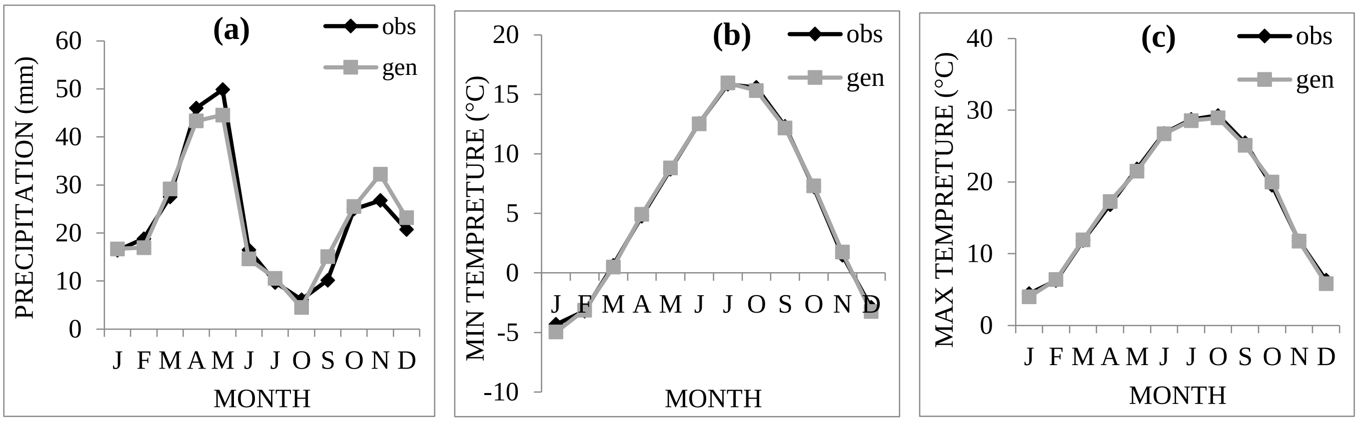


Figure 2. Comparison of observed and generated values for precipitation (a), minimum temperature (b), and Maximum temperature (c) in Ahar synoptic station

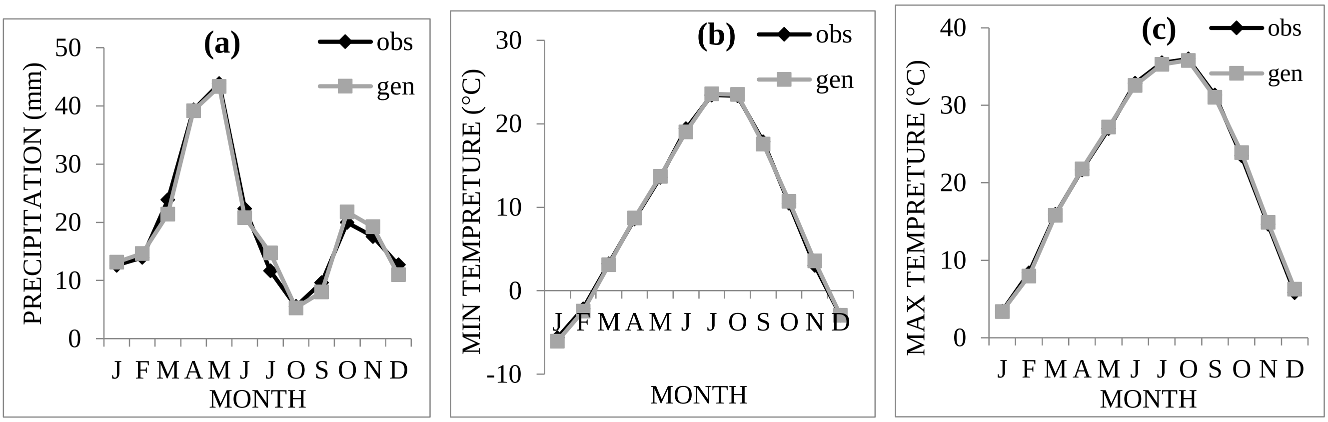


Figure 3. Comparison of observed and generated values for precipitation (a), minimum temperature (b), and Maximum temperature (c) in Jolfa synoptic station

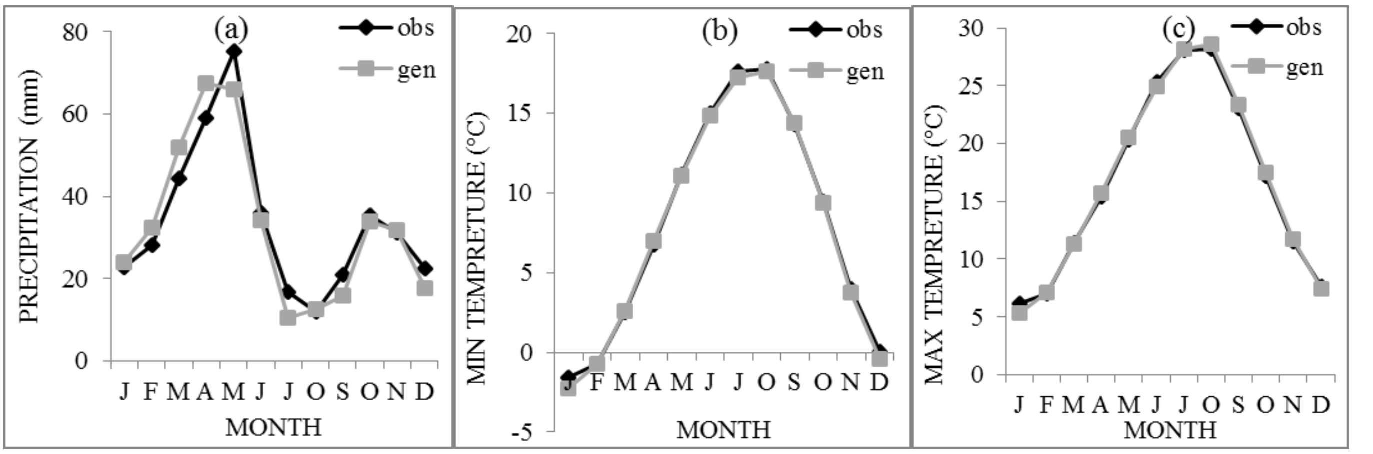


Figure 4. Comparison of observed and generated values for precipitation (a), minimum temperature (b), and Maximum temperature (c) in Kaleybar synoptic station

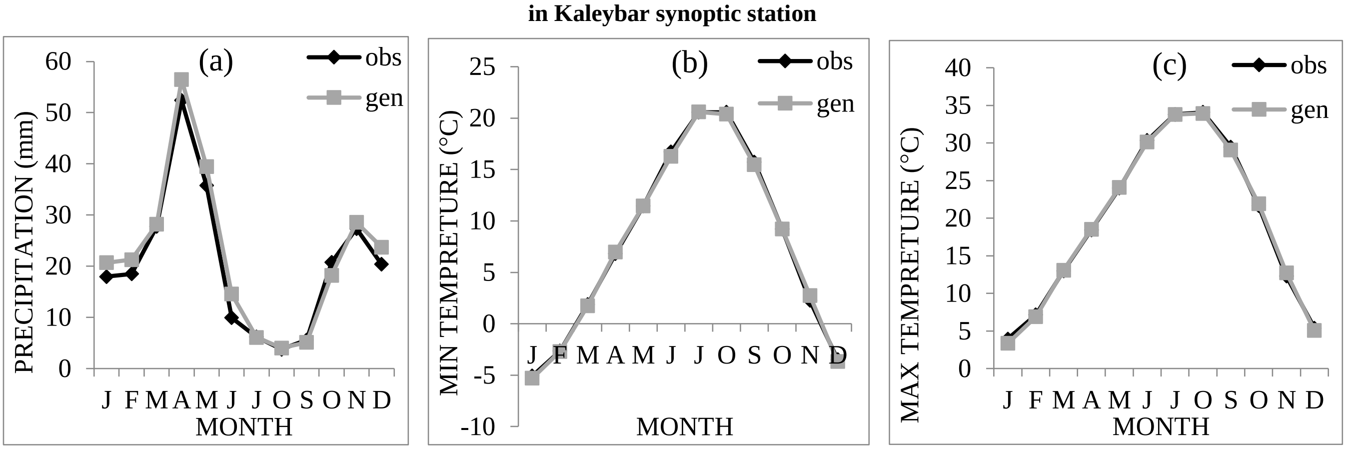


Figure 5. Comparison of observed and generated values for precipitation (a), minimum temperature (b), and Maximum temperature (c) in Tabriz synoptic station

3.2. Comparing and mapping changes in climate parameters

Comparison of the past (observed data) and future (generated data) climate changes showed relative changes in the different parameters under various scenarios for each station. Table 2 to 5 shows the changes in Tmin, Tmax, precipitation, As shown in Table 2, the results of comparisons between observed data (obtained from baseline data of synoptic stations for 2000-2017) and generations data (obtained from simulated data of LARS-WG model scenarios for 2011-2030) showed that the Tmin and Tmax would be decreased in Ahar station (0.1 -0.2 °C). The precipitation level is increased (17 – 20.4 mm). Based on Table 3, the average annual Tmin will be reduced (0.2 - 0.4 °C) and Tmax will be increased (0.2 °C). Annual precipitation will be changed from -0.3 mm up to 10.5 mm in Jolfa station. The results of Kaleybar station in Table 4 revealed that Tmin will be increased in approximately 4.5 °C. Tmax will increase 1.1 °C, The amount of annual precipitation will be decline 10.1 – 46.4 mm. in addition (Table 4).Annual past and future changes in climate parameters in Tabriz station demonstrated that Tmin and Tmax will be increased by approximately 0. –0.2 °C. The mean annual precipitation will be increased (7.1 up to 10.3 mm) (Table 5).

Table 2. Annual past changes during 2000-2017 (observed) and future changes during 2018-2030 (generated) of total precipitation, average minimum temperature (T_{min}), average maximum temperature (T_{max}), and average solar radiation under A1B, A2 and B1 scenarios in Ahar station.

Ahar station		Average of T_{min}				Average of T_{max}				Sum of Precipitation				Average of Solar Radiation			
Observed year	Predicted year	Observed	Predicted			Observed	Predicted			Observed	Predicted			Observed	Predicted		
			A1B	A2	B1		A1B	A2	B1		A1B	A2	B1		A1B	A2	B1
2000	2018	5.8	6.0	6.1	6.1	17.3	17.8	17.9	17.9	243.5	341.3	338.2	340.3	7.4	16.2	16.2	16.2
2001	2019	6.5	5.9	6.0	6.0	18.3	17.6	17.7	17.7	190.7	258.3	256.9	259.4	7.7	15.8	15.9	15.8
2002	2020	5.8	5.9	6.0	6.0	17.6	17.8	17.9	17.9	268.2	322.2	319.5	320.5	7.5	16.0	16.0	16.0
2003	2021	6.0	6.2	6.3	6.3	16.3	17.1	17.2	17.2	274.2	259.2	255.8	262.0	6.7	16.2	16.2	16.2
2004	2022	5.7	5.7	5.8	5.8	17.4	17.3	17.4	17.4	365.3	293.8	291.9	293.8	7.5	15.8	15.8	15.8
2005	2023	5.8	5.9	6.0	6.0	17.4	17.6	17.7	17.7	236.5	233.4	232.2	235.5	7.6	15.7	15.7	15.7
2006	2024	5.9	5.7	5.8	5.8	17.7	17.2	17.3	17.3	283.5	330.1	327.8	333.6	7.7	15.4	15.5	15.5
2007	2025	5.4	5.9	6.0	6.0	16.7	18.4	18.5	18.5	335.4	225.3	223.7	225.4	7.4	16.1	16.1	16.1
2008	2026	5.4	5.9	6.0	6.0	16.8	17.5	17.5	17.5	206.5	300.1	297.0	302.7	7.1	16.1	16.1	16.1
2009	2027	5.8	6.0	6.1	6.1	17.1	17.8	17.9	17.9	182.9	232.8	230.8	233.8	6.9	16.1	16.1	16.1
2010	2028	7.2	5.8	5.9	5.9	20.1	17.5	17.6	17.6	276.4	316.9	315.9	320.7	7.6	15.2	15.2	15.2
2011	2029	5.1	6.2	6.3	6.3	15.7	17.7	17.8	17.8	337.8	332.8	330.1	333.7	6.7	16.0	16.1	16.1
2012	2030	6.3	6.0	6.1	6.1	17.8	17.1	17.2	17.2	290.0	324.0	321.2	323.6	7.2	15.8	15.9	15.9
2013		5.7				17.3				298.7				7.7			
2014		6.8				18.3				272.4				7.5			
2015		6.5				18.4				386.7				7.3			
2016		6.4				18.8				253.8				7.1			
2017		7.1				19.9				171.8				8.4			
Average		6.1	5.9	6.0	6.0	17.7	17.6	17.7	17.7	270.8	290.0	287.8	291.2	7.4	15.9	15.9	15.9

Table 3. Annual past changes during 2000-2017 (observed) and future changes during 2018-2030 (generated) of total precipitation, average minimum temperature (T_{min}), average maximum temperature (T_{max}), and average solar radiation under A1B, A2 and B1 scenarios in Jolfa station.

Jolfa station		Average of T_{min}				Average of T_{max}				Sum of P				Average of Rad			
		Observed	Predicted			Observed	Predicted			Observed	Predicted			Observed	Predicted		
Observed year	Predicted year		A1B	A2	B1		A1B	A2	B1		A1B	A2	B1		A1B	A2	B1
2000	2018	10.1	9.7	9.74	9.7	21.7	21.8	21.88	21.9	129.3	180.6	180.10	181.2	7.9	16.4	16.38	16.4
2001	2019	10.9	9.8	9.87	9.9	22.4	21.8	21.91	21.9	155.5	248.5	247.30	248.8	7.6	16.6	16.64	16.6
2002	2020	9.0	9.7	9.78	9.8	20.8	21.1	21.17	21.2	219.2	249.9	249.50	251.5	7.6	16.6	16.64	16.6
2003	2021	9.6	9.7	9.78	9.8	19.9	21.7	21.78	21.8	306.9	211.3	210.80	212.9	7.1	16.4	16.38	16.4
2004	2022	9.6	9.8	9.91	9.9	20.8	21.6	21.69	21.7	323.6	302.9	302.80	305.0	7.6	16.1	16.15	16.1
2005	2023	9.4	9.7	9.82	9.8	20.8	22.5	22.60	22.6	237.3	215.2	213.40	215.1	7.6	16.7	16.69	16.7
2006	2024	10.0	9.4	9.44	9.4	21.7	21.1	21.25	21.3	200.6	337.2	339.70	343.0	7.5	16.4	16.44	16.4
2007	2025	9.8	9.3	9.91	9.9	20.7	21.3	21.77	21.8	230.4	247.0	185.00	187.0	7.3	16.3	16.44	16.4
2008	2026	9.2	9.4	9.90	9.9	21.2	21.5	21.50	21.5	178.5	250.3	229.00	230.5	7.7	15.5	16.25	16.2
2009	2027	9.3	9.7	9.52	9.5	20.8	21.4	22.08	22.1	224.8	239.8	279.40	282.6	7.2	16.2	15.98	16.0
2010	2028	10.9	9.3	9.68	9.7	23.7	21.8	21.74	21.8	349.1	230.4	141.50	142.8	7.6	16.5	16.33	16.3
2011	2029	9.4	9.8	9.70	9.7	20.5	21.7	21.63	21.6	252.0	199.7	168.20	169.5	7.1	16.3	16.37	16.4
2012	2030	10.6	9.9	9.93	9.9	22.2	21.8	21.90	21.9	257.5	231.8	218.30	220.0	7.7	16.6	16.59	16.6
2013		9.4				21.3				223.8				7.8			
2014		11.1				22.6				215.0				7.5			
2015		10.6				23.0				250.6				7.7			
2016		10.2				21.7				257.4				7.4			
2017		11.2				22.9				153.9				8.0			
Average		10.0	9.6	9.8	9.8	21.6	21.6	21.8	21.8	231.4	241.9	228.1	230.0	7.5	16.4	16.4	16.4

Table 4. Annual past changes during 2000-2017 (observed) and future changes during 2018-2030 (generated) of total precipitation, average minimum temperature (T_{min}), average maximum temperature (T_{max}), and average solar radiation under A1B, A2 and B1 scenarios in Kaleybar station.

Kaleybar station		Average of T_{min}				Average of T_{max}				Sum of P				Average of Rad			
		Observed	Predicted			Observed	Predicted			Observed	Predicted			Observed	Predicted		
Observed year	Predicted year		A1B	A2	B1		A1B	A2	B1		A1B	A2	B1		A1B	A2	B1
2000	2018	0.6	8.0	8.1	8.2	10.2	17.1	17.2	17.6	323.9	313.4	310.8	246.4	6.9	15.1	15.1	15.4
2001	2019	8.5	8.5	8.6	8.3	17.8	17.2	17.2	17.2	305.3	397.4	395.4	396.4	6.9	15.1	15.1	14.9
2002	2020	7.9	8.2	8.3	8.5	16.8	17.1	17.2	17.5	414.2	399.6	398.4	428.6	6.8	14.3	14.4	14.4
2003	2021	-2.0	8.0	8.1	8.0	10.0	16.5	16.5	16.7	507.8	383.4	380.1	540.5	5.7	14.3	14.3	14.8
2004	2022	-2.2	7.9	8.0	8.5	16.8	16.8	16.9	16.9	433.3	438.1	434.8	413.6	6.8	14.9	14.9	14.7
2005	2023	8.2	8.7	8.7	8.3	16.6	17.3	17.4	17.5	305.4	306.2	305.1	368.7	6.5	15.3	15.3	14.4

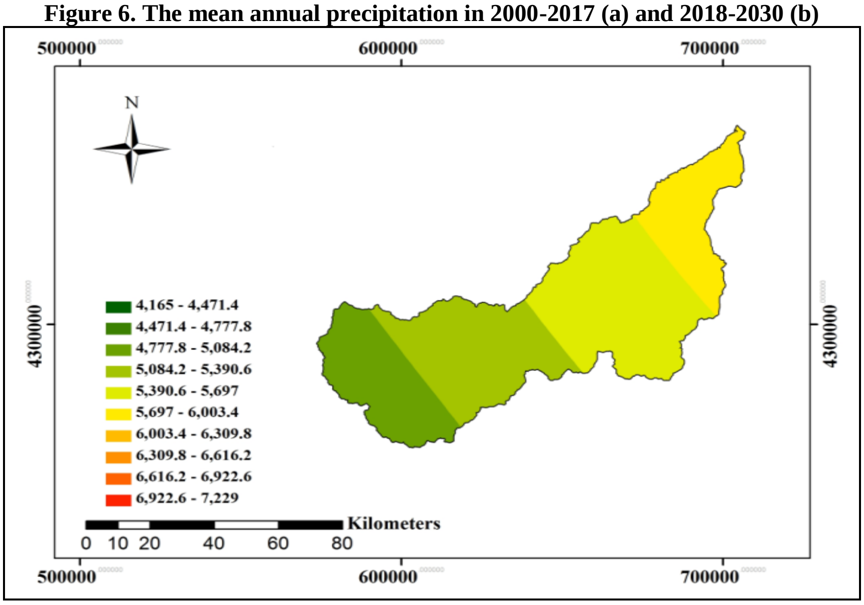
2006	2024	0.9	8.1	8.2	8.1	17.2	17.5	17.6	17.0	298.5	357.5	353.9	479.9	7.0	14.4	14.4	14.4
2007	2025	7.8	8.3	8.4	8.1	16.6	17.3	17.4	17.6	422.5	329.4	326.8	409.4	6.5	15.4	15.4	15.1
2008	2026	7.9	8.0	8.1	8.4	16.4	17.2	17.2	17.0	359.9	311.8	309.6	405.8	6.4	15.4	15.4	15.2
2009	2027	8.0	8.2	8.3	8.3	16.6	17.7	17.8	17.0	447.6	236.6	236.3	266.7	6.1	15.0	15.0	14.9
2010	2028	0.2	8.2	8.3	8.4	18.6	16.5	16.6	17.0	418.6	407.5	405.0	379.9	6.9	13.6	13.6	14.4
2011	2029	7.0	7.9	7.9	7.9	15.1	16.6	16.7	17.1	562.0	398.7	397.8	352.9	6.1	15.1	15.1	14.7
2012	2030	2.7	8.4	8.5	8.7	16.7	17.5	17.6	17.3	393.6	365.2	363.7	401.3	6.4	15.2	15.2	15.2
2013		7.9				16.9				349.5				6.9			
2014		-1.4				16.4				484.6				6.9			
2015		-0.9				17.2				492.4				6.9			
2016		-2.3				16.2				422.4				6.8			
2017		9.2				18.9				287.2				7.5			
Average		3.7	8.2	8.3	8.3	16.1	17.1	17.2	17.2	401.6	357.3	355.2	391.5	6.6	14.8	14.9	14.8

Table 5. Annual past changes during 2000-2017 (observed) and future changes during 2018-2030 (generated) of total precipitation, average minimum temperature (T_{min}), average maximum temperature (T_{max}), and average solar radiation under A1B, A2 and B1 scenarios in Tabriz station.

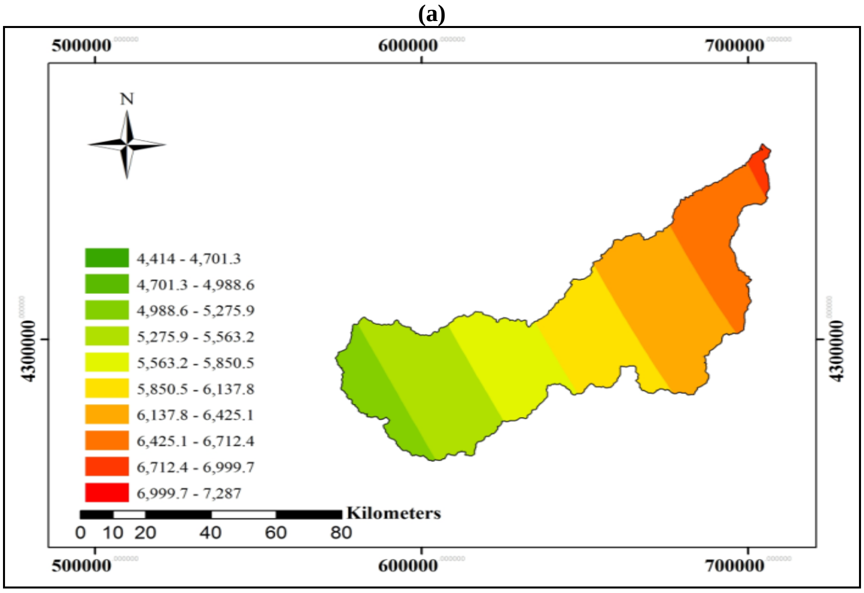
Tabriz station		**Average of T_{min}**				**Average of T_{max}**				**Sum of P**				**Average of Rad**			
Observed year	Predicted year	Observed	Predicted			Observed	Predicted			Observed	Predicted			Observed	Predicted		
			A1B	A2	B1		A1B	A2	B1		A1B	A2	B1		A1B	A2	B1
2000	2018	8.7	8.3	8.4	8.4	19.7	19.9	19.9	19.9	204.9	192.3	191.3	192.8	8.0	16.9	16.9	16.9
2001	2019	8.9	8.2	8.3	8.3	20.0	19.6	19.7	19.7	203.7	307.6	305.3	308.7	8.1	16.8	16.8	16.8
2002	2020	7.7	8.1	8.2	8.1	18.9	20.0	20.1	20.1	302.9	239.4	238.2	241.2	7.9	16.8	16.8	16.8
2003	2021	8.4	8.6	8.6	8.6	19.2	19.9	20.0	20.0	218.9	206.3	205.4	208.1	7.6	16.9	16.9	16.9
2004	2022	8.2	8.4	8.4	8.4	19.6	19.5	19.6	19.6	284.8	311.7	309.4	314.1	8.2	16.8	16.8	16.8
2005	2023	8.3	8.1	8.2	8.2	19.1	19.9	20.0	20.0	233.3	285.0	283.2	286.9	8.1	16.3	16.3	16.3
2006	2024	8.5	8.3	8.3	8.3	19.7	19.6	19.7	19.7	305.1	225.4	223.5	226.2	7.9	16.9	17.0	17.0
2007	2025	7.2	8.0	8.1	8.1	18.9	19.6	19.6	19.6	230.0	290.7	289.3	290.7	7.7	17.2	17.3	17.3
2008	2026	7.5	7.9	8.0	8.0	19.6	19.0	19.1	19.1	171.5	271.8	271.3	274.3	7.9	16.7	16.7	16.7
2009	2027	7.7	7.9	8.0	8.0	19.3	19.7	19.8	19.8	241.9	156.3	155.6	158.3	7.0	17.0	17.0	17.0
2010	2028	9.3	8.1	8.2	8.2	21.7	19.6	19.7	19.7	183.9	221.7	221.4	224.4	7.9	16.9	16.9	16.9
2011	2029	7.0	8.0	8.1	8.1	18.5	19.7	19.8	19.8	282.2	256.8	255.7	259.5	7.6	17.2	17.2	17.2
2012	2030	8.4	8.4	8.5	8.4	20.0	20.0	20.1	20.1	217.2	311.8	310.0	315.8	7.9	16.6	16.6	16.6
2013		7.4				19.3				262.5				8.1			
2014		8.4				20.1				311.0				7.9			
2015		8.3				20.0				287.1				7.7			
2016		7.4				20.0				291.0				7.9			
2017		9.0				21.6				152.1				8.7			
Average		8.1	8.2	8.3	8.2	19.7	19.7	19.8	19.8	243.6	252.1	250.7	253.9	7.9	16.9	16.9	16.9

In the next section the distribution maps of changes these climate parameters (past vs. future was shown in Figures 6 to 8).

Figure 6. The mean annual precipitation in 2000-2017 (a) and 2018-2030 (b)

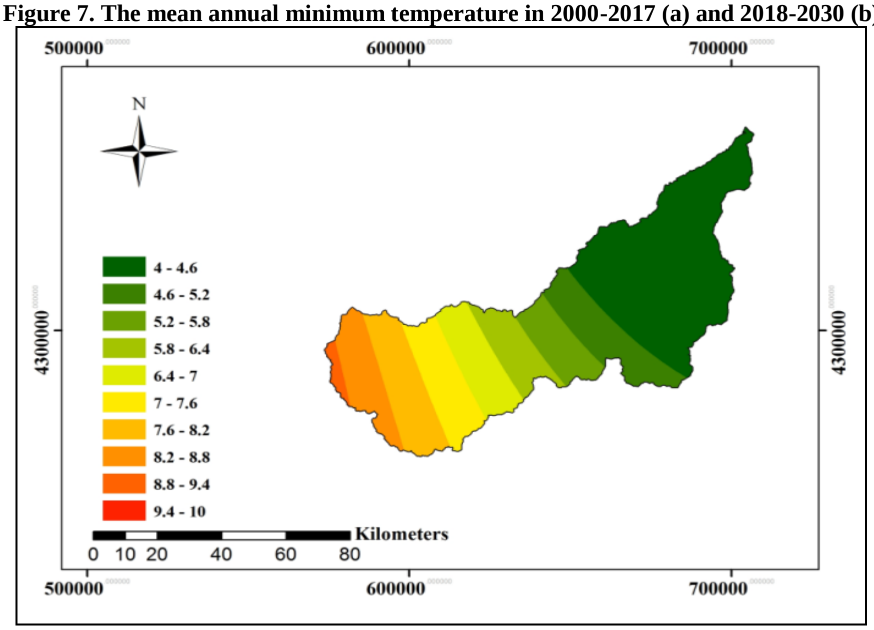


(a)

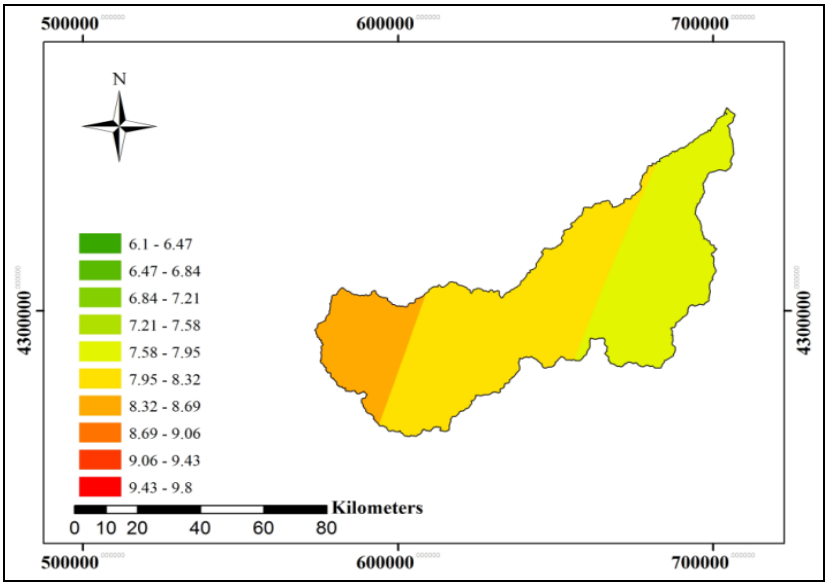


(b)

Figure 7. The mean annual minimum temperature in 2000-2017 (a) and 2018-2030 (b)

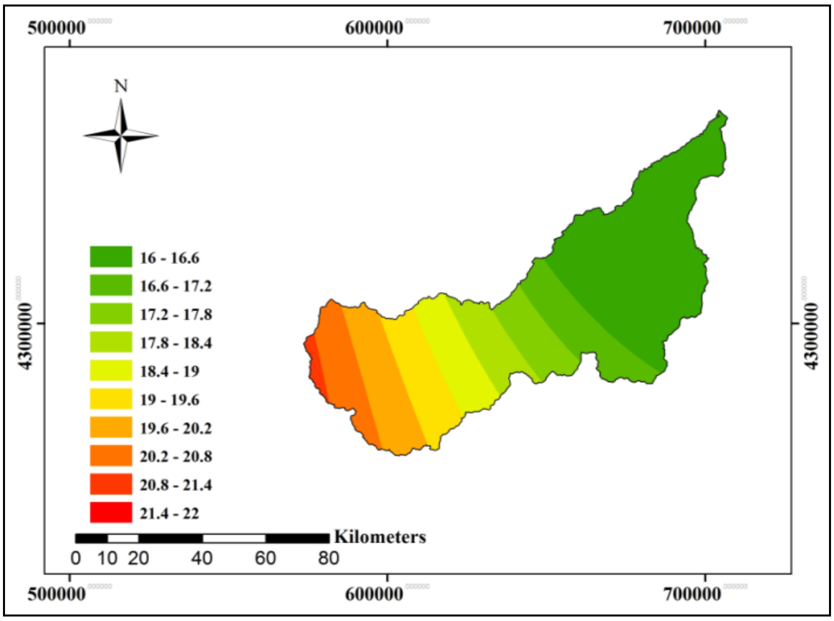


(a)

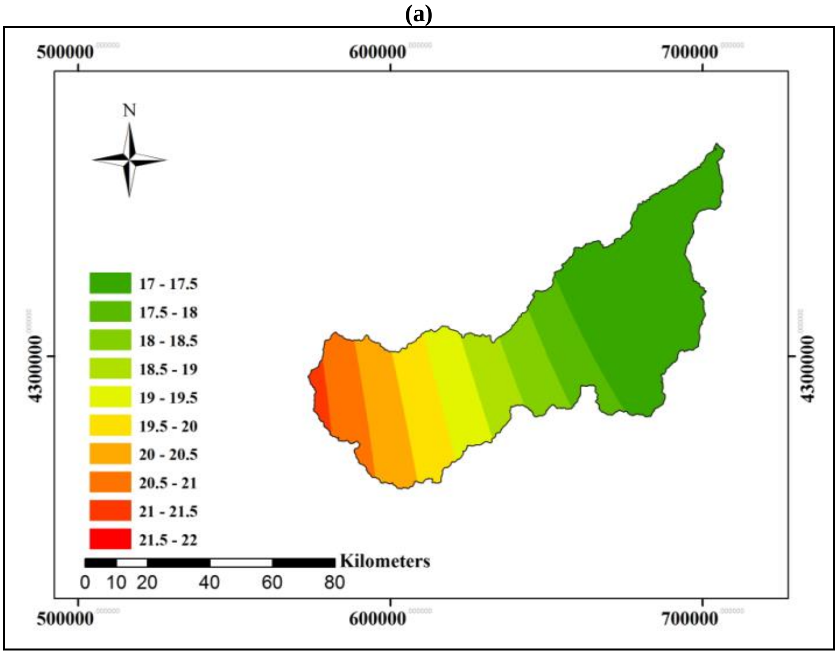


(b)

Figure 8. The mean annual maximum temperature in 2000-2017 (a) and 2018-2030 (b)



(a)



(b)

Results of the simulation the seasonal distribution of the wet/dry and frost/heat spells showed that DJF has no heat spells and JJA has no frost spells in all stations. Table 6 presents these results.

Table 6. K-S test for seasonal wet / dry and Frost/heat spells distribution for stations

Season	Wet/Dry	N	K-S	P-value	Frost/Heat	N	K-S	P-value
Ahar station								
DJF	wet	12	0.089	1	frost	12	0.112	0.998
DJF	dry	12	0.049	1	No heat spells			
MAM	wet	12	0.291	0.238	frost	12	0.14	0.966
MAM	dry	12	0.027	1	heat	12	0.13	0.984
JJA	wet	12	0.263	0.350	No frost spells			
JJA	dry	12	0.078	1	heat	12	0.445	0.014
SON	wet	12	0.034	1	frost	12	0.214	0.613
SON	dry	12	0.21	0.637	heat	12	0.21	0.637
Jolfa station								
DJF	wet	12	0.055	1	frost	12	0.13	0.984
DJF	dry	12	0.163	0.8925	No heat spells			
MAM	wet	12	0.03	1	frost	12	0.217	0.595
MAM	dry	12	0.09	1	heat	12	0.287	0.252
JJA	wet	12	0.05	1	No frost spells			
JJA	dry	12	0.043	1	heat	12	0.109	0.998
SON	wet	12	0.044	1	frost	12	0.07	1
SON	dry	12	0.039	1	heat	12	0.274	0.303
Kaleybar station								
DJF	wet	12	0.319	0.1552	frost	12	0.23	0.520
DJF	dry	12	0.039	1	No heat spells			
MAM	wet	12	0.297	0.218	frost	12	0.317	0.160
MAM	dry	12	0.049	1	heat	12	0.217	0.595
JJA	wet	12	0.111	0.9978	No frost spells			
JJA	dry	12	0.036	1	heat	12	0.187	0.772
SON	wet	12	0.265	0.3411	frost	12	0.248	0.423
SON	dry	12	0.1	0.9996	heat	12	0.131	0.982
Tabriz station								
DJF	wet	12	0.063	1	frost	12	0.111	0.998
DJF	dry	12	0.028	1	No heat spells			
MAM	wet	12	0.065	1	frost	12	0.108	0.999
MAM	dry	12	0.04	1	heat	12	0.261	0.359
JJA	wet	12	0.278	0.286	No frost spells			
JJA	dry	12	0.058	1	heat	12	0.173	0.847
SON	wet	12	0.049	1	frost	12	0.149	0.943
SON	dry	12	0.08	1	heat	12	0.296	0.221

Climate change could significantly alter productivity, ecosystem function, structure, and type of forests. Rapid climate change has great potential to change the distribution and species composition of forest vegetation, threaten forest ecosystems, and even reduce biodiversity and the availability of ecosystem services. Therefore, modeling climate change will need to account for many ecosystems (Wan et al. 2017, Herr et al. 2016). Downscaling climate models could improve local scale studies' accuracy (Moreno and Hasenauer, 2016). In order to resource management, to understand the magnitude and timing the impacts of climate change and their effects on the local and regional resources, it must be able to study the climate scenarios of key climate variables for future periods (Farzanmanesh et al. 2012).This study contains new information about the Arasbaran forest climate as an important divers forest ecosystem in Iran that there was no study in before at all. Since that, there were no previous results and similar studies to comparison in this study area. However, Farzanmanesh et al. (2012) concluded that mean temperature and precipitation would increase during 2010-2030 in the north and northeast of Iran according to LARS-WG scenarios. They illustrated that the LARS-WG model has a reasonable capability of simulating the minimum and maximum temperatures and precipitation. However, our results show an agreement with them. A small difference in average monthly parameters was recorded by the LARS-WG model; therefore, the LARS model was able to perform simulation future year's climate well in these parameters in our study. These results were according to the results of Goodarzi et al. (2014), Chisanga et al. (2017) and Hassan et al. (2014) that reported similar findings for performing the LARS-WG model to prediction and show a good agreement between observed and simulated data analysis. Nevertheless, the application of other models is recommended in order to achieve more reliable simulated results. So that, Hassan et al. (2014) stated that the SDSM model was robust in climate variables including temperature and precipitation downscalingcompared to the LARS model while the LARS model was able to downscale dry and wet spells very well. In addition, the A1B and B1 have been introduced as efficient technologies and ecologically friendly to downscaling of precipitation and temperature by the LARS-WG model (2017).King et al. (2012) reported that LARS-WG simulates precipitation events well but cannot produce means and variance in the daily temperate series in the study of the effects of climate change on extreme precipitation events in the upper Thames River basin in Ontario Canada as the region with similar environmental factors as the present study area. In this study, it can be concluded that the northern parts of the Arasbaran forest will face more precipitation and warmer temperature in the future. Therefore, the climate of the Arasbaran forest (the Aras river basin region) would experience warmer temperature and more annual precipitation due to the northern parts of this forest area is influenced mostly by the humidity originated in Aras River and proximity to urban areas especially the Tabriz city as the capital of the province in the south parts. Zarghami et al. (2011) also introduced rapid urbanization and industrial activities as the key factors of increasing temperature that will have significant impacts on the ecosystems such as less rain, warmer seasons and facing droughts in the future. As well as, Hassan et al. (2014) emphasized on ambient temperature and maritime influence on climatic condition. Therefore, find urgent appropriate strategies will be necessary.

4. Conclusions

In this study, meteorological parameters of Arasbaran forest including precipitation, minimum, and maximum temperature, were simulated using the LARS weather generator under A1B, A2, and B1 scenarios. The results of simulating and mapping showed that precipitation, minimum temperature, and maximum temperature will increase. Increasing the minimum and maximum temperature and the amount of radiation can be a sign of warming the climate in these forests. The results of this study could be used in strategic plans research on understanding climate change impacts on trees increments, species distribution and climate change impacts such as heavy rain events, wind storms, and drought on forests. This study helps to enable the generation of native species and national territories and significantly helps the managers and decision-makers to produce practicable and reliable decisions.

Acknowledgements

Thanks to the General Office of Applied Meteorology Research Center of East-Azarbayjan province for the data preparation and University of Tabriz research offer office to support financial supports.

References

- Wan, J.Z., Wang, C.J., Qu, H., Liu, R., Zhang, Z.X. (2017) Vulnerability of forest vegetation to anthropogenic climate change in China, Sci Total Environ, 15 (621):1633-1641.
- Xiao-Ying, W., Chun-Yu, Z., Qing-Yu, J. 2013. Impacts of Climate Change on Forest Ecosystems in Northeast China, Adv Climate Change Res. 4(4): 230-241.
- Espeland, E.K., Kettenring, K.M. 2018. Strategic plant choices can alleviate climate change impacts: A review. J of Environ Manag. 222: 316–324.
- Moreno, A., Neumann, M., Hasenauer, H. 2018. Climate limits on European forest structure across space and time. Glob Planetary Change, 169: 168-178.
- Pirovani, D.B., Pezzopane, J.E.M., Xavier, A.C., Pezzopane. J.R.M. et al. 2018. Climate change impacts on the aptitude area of forest species. Ecol Indicators. 95: 405-416.
- Brecka, A.F.J., Shahi, C., Chen, H.Y.H. 2018. Climate change impacts on boreal forest timber supply. Forest Pol Econ, 92: 11–21.
- Lasco, R.D., Pulhin, F.B., Sanchez, P.A.J., Villamor, G.B., Villegas, K.A.L. 2008. Climate Change and Forest Ecosystems in the Philippines: Vulnerability, Adaptation and Mitigation. J of Environ Sci Manag. 11(1):1-14.
- Keenan, R.J. 2016. Forests and Climate Change: Introduction to a special section. Forest Ecol Manag, 360: 353–356.
- Fischer, A.P. 2019. Characterizing behavioral adaptation to climate change in temperate forests. Landscape Urb Plan. 188: 72-79.
- Herr, A., Dambacher, J.M., Pinkard, E., Glen, M., Mohammed, C., Wardlaw, T. 2016. The uncertain impact of climate change on forest ecosystems - How qualitative modelling can guide future research for quantitative model development. Environ Model Soft. 76: 95-107.
- Booth, T.H. 2018. Species distribution modelling tools and databases to assist managing forests under climate change. Forest Ecol Manag, 430: 196–203.

- Klapwijk, M.J., Boberg, J., Bergh, J., Bishop, K., Björkman, C., Ellison, D., Felton, A., Lidskog, R., Lundmark, T., Keskitalo, E.C.H., Sonesson, J., Nordin, A., Nordströml, E.M., Stenlid, J., Marald, E. 2018. Capturing complexity: Forests, decision-making and climate change mitigation action. Glob Environ Change. 52: 238–247.
- Lagergren, F., Jonsson, A.M. 2017. Ecosystem model analysis of multi-use forestry in a changing climate. Ecosystem Ser, 26: 209–224.
- Ovando, P., Caparros, A. 2009. Land use and carbon mitigation in Europe: A survey of the potentials of different alternatives. Energy Policy. 37: 992–1003.
- Zarghami, M., Abdi, A., Babaeian, I., Hassanzadeh, Y., Kanani, R. 2011. Impacts of climate change on runoffs in East Azerbaijan, Iran, Global Planetary Change. 78: 137-146.
- Goodarzi, E., Bavani, A.R.M., Dastorani, M.T., Talebi, A. 2014. Evaluating effect of downscaling method; change-factor and LARS-WG on surface runoff (A case study of Azam-Harat River basin, Iran), Desert. 19 (2): 99-109.
- Ding, H., Chiabai, A., Silvestri, S., Nunes, P.A.L.D. 2016. Valuing climate change impacts on European forest ecosystems. Ecosystem Serv. 18: 141–153.
- Moreno, A., Hasenauer, H. 2016. Spatial downscaling of European climate change data. International J of Climatology. 36: 1444-1458.
- Chisanga, C.B., Phiri, E., Chinene, V.R.N. 2017. Statistical downscaling of precipitation and temperature using Long Ashton research station weather generator in Zambia: a case of Mount Makulu Agriculture Research Station, American J Climate Change. 6: 487-512.
- Rasuly, A., Naghdifar, R., Rasoli, M. 2010. Detecting of Arasbaran Forest Changes Applying Image Processing Procedures and GIS Techniques. Procedia Environmental Sci. 2:454-464.International Society for Environmental Information Sciences 2010 Annual Conference (ISEIS) Detecting of Arasbaran Forest Changes Applying Image Processing Procedures and GIS Techniques.
- Talebi, Kh.S., Sajedi, T., Pourhashemi, M. 2014. Forests of Iran, A Treasure from the Past, a Hope for the Future, springer, 152 pp.
- Farzanmanesh, R., Abdullah, A.M., Shakiba, A., Amanollahi, J. 2012. Impact Assessment of Climate Change in Iran using LARS-WG Model. Pertanika J Sci Technol. 20(2): 299 – 311.
- Rashidian, L. 2017. Study of the process of climate change according to data simulation using lars-wg software during 2010-2030: case study of Semnan province. Int Scholarly Sci Res Innov. 11(9): 848-851.
- Semenov, M.A., Brooks, R.J. 1999. Spatial interpolation of the LARS-WG stochastic weather generator in Great Britain, Climate Res. 11: 137–148.
- Zia Hashmi, M., Shamseldin, A.Y., Melville, B.W. 2011. Comparison of SDSM and LARS-WG for simulation and downscaling of extreme precipitation events in a watershed. Stoch Environ Res Risk Assess. 25: 475-484.
- Semenov, M.A., Barrow, E.M. 2002. LARS-WG A Stochastic Weather Generator for Use in Climate Impact Studies. Version 3.0 User Manual. 28 p.
- Hassan, Z., Shamsudin, S., Harun, S. 2014. Application of SDSM and LARS-WG for simulating and downscaling of rainfall and temperature, Theoretical App Clim. 116: 243-257.
- Tareghian, R., Rasmussen, P.F. 2013. Statistical downscaling of precipitation using quantile regression, J Hydrology. 487: 122–135.
- King, L.M., Irwin, S., Sarwar, R., McLeod, A.I., Simonovic, S.P. 2012. The Effects of Climate Change on Extreme Precipitation Events in the Upper Thames River Basin: A Comparison of Downscaling Approaches. Canadian Water Resources J. 37 (3): 253-274.