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Adaptation of global climate change projections for local level application: Case study, special forest ecosystem, Astara

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Abstract
During recent years, a series of climate projections provided for surface temperature increase and precipitation changes over the next century in various time slices. National institutes are using downscaling projections for more precise results. In this research study, various climate change projections in global, continental, regional and local scales have been examined in special forest ecosystem in Astara. To study past climate conditions, main climatic factors namely temperature and precipitation as well as relative humidity and wind were considered. Downscaling climate projections in national and local scales have some agreement and disagreement with available global, continental and regional projections. According to all reports in different scales temperature of Astara region, in last half century has been increased. In the longer future time period, the study area will face with higher values of increasing temperature. According to the scenario A1B (2090-2099) in the winter, western part of Hyrcanian forest including Astara will experience 10% increment of precipitation and in the summer 20% decrement of precipitation. This is in agreement with Central Asia sub-region projection and in disagreement with West Asia sub-region projection. For the future projection of precipitation in Astara area, there are no significant differences between global, Central Asia sub-region, Middle East, national and local downscaling projections.

Key words: Climate change; Global projections; Local application; Astara forest ecosystem; Iran

Introduction
The Intergovernmental Panel on Climate Change (IPCC) published the Fourth Assessment Report (AR4) in 2007 and stated that recent climate change and variation are induced by increases in the atmospheric greenhouse gases (GHG) concentration due to anthropogenic activities. The report includes the results of impact assessments on a wide range of sectors. These assessments have been conducted based on future climate projections, which refer to aspects of the future climate evaluated by Atmosphere-Ocean Coupled General Circulation Models (CGCMs) (Okada, *et al.*, 2009). In climate change studies context, international, regional and national research institutes according to the available data and scenarios analyze past conditions and will provide projection for the future climate changes (Cruz *et al.*, 2007; Jafari, 2007b). Estimates for the likelihood of future climate changes in different county were made based on the projection from the IPCC climate models (Hsu and Chen, 2002). Therefore, provided results are different in time scales, scenarios and study areas and may not be adapted precisely. With the set of models showing increasing agreement in their simulations of twentieth-century trends in climate and of projected changes in climate on sub-continental to continental scales, the climate scenarios that were generated seem likely to provide a plausible representation of the types of climatic conditions that could be experienced during the twenty-first century (MacCracken *et al.*, 2003).
Forest and forestry are very valuable resources in Iran (Jafari, 1997a and 1997b), and play important role in climate change in the region (Jafari, 2006; Jafari, 2007a).
Different countries (Wang and Zhang, 2008), are using climate down scaling method to take

more accurate results in national or provincial levels. However, significant differences remain in the projection of changes in precipitation and of the regional departures in climate from the larger-scale patterns (MacCracken *et al*., 2003).

Material and Methods

Astara forest, from geographical, topographical and climatic points of views is an especial and unique ecosystem (Fig. 1, Table 1). In this investigation, various climate change projections in global, continental, regional and local scales have been examined in the special forest ecosystem in Astara. All analysis and projections include and cover study area. To study past climate conditions, main climatic factors namely temperature and precipitation as well as relative humidity and wind were considered.

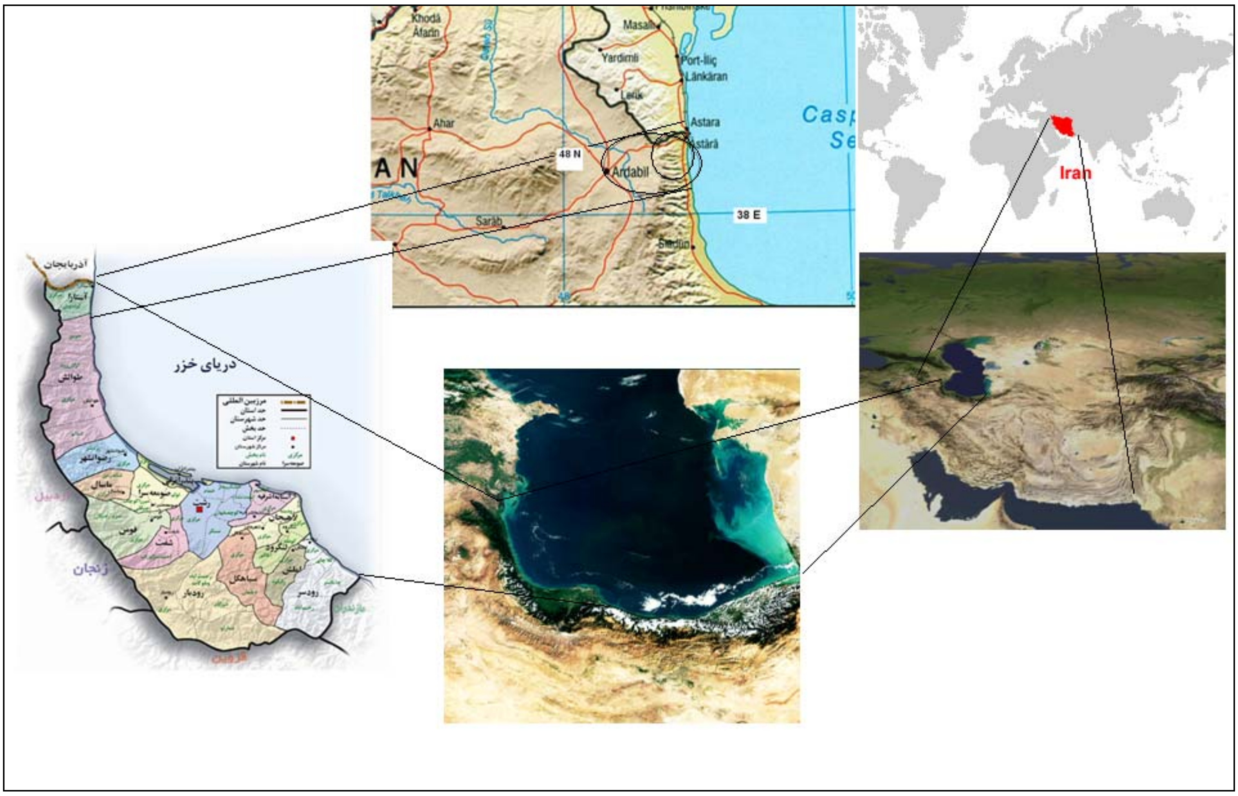

Fig. 1- Astara study location map (Maps from different sources).

Table 1- Forest study zone and location of meteorology stations in Astara and Ardebil

Region / stations	Elevation from sea level (m)	Longitude E	Latitude N	Stations Code
Astara Chay forest – No. 1	Min. 0 and Max. 1750 m and majority of forest in 100 -1000 m	48 51 E and 48 34 E	38 26 N and 38 17 N	(region no. 1)
Astara Synoptic	-18.0	48 52 E	38 25 N	40709
Astara Climatology	+25	48 52 E	38 26 N	
Ardebil	+1350	48 17 E	38 15 N	

Global projections

IPCC used different models and scenarios to provide climate projection in global, continental and regional levels (IPCC, 2007). According to provided projection by IPCC, changes in precipitation and temperature could be considered in different scales from global to local levels.

Temperature

Based upon data provided in the map of changes in surface temperature by IPCC (IPCC, 2007), surface temperature in whole Iran except small area in south in period of 1970 -2004 increased between 1 to 2 °C.
According to the map of geographical pattern of surface warming; projected surface

temperature will change by the late 21st century (2090-2099), relative to the period 1980-1999, surface temperature in north of Iran based upon Atmosphere-Ocean General Circulation Model (AOGCM) and A1B SRES will increase between 3 to 3.5°C and central and southern part will experience increase of 4°C and more (IPCC, 2007). While, global mean of temperature depend on scenarios and region will experience of 1.1 to 6.4 degrees increase which will cause sea level rise of 0.18 to 0.59 meter (source: Table 3.1 SPM, IPCC, 2007).

According to the AOGCM projections of surface warming; projected surface temperature changes for the early and late 21st century relative to the period 1980-1999, show the multi-AOGCM average projections for the A2, A1B and B1 SRES scenarios averaged over decades 2020-2029 and 2090-2099 (Source: WGI 10.4, 10.8 Figs. 10.28, 10.29, SPM and Fig. 3.2, IPCC, 2007), provided by IPCC (IPCC, 2007), Iran's surface temperature will increase 1-2°C for 20s and 4 - 5.5 for 90s. The rates are increasing from B1 to A2 (IPCC, 2007).

Precipitation

Based upon mean of models and according to scenario A1B in 90s of 21st century (2090-2099) comparing with 80s (1980-1999) amount of precipitation in winter season (Dec. to Feb.) in west of Iran will reduce up to 10% and in the western part of Caspian Sea will increase up to 10% (Fig. 2 left panel). While, in the same condition in summer season (June to Aug.), North and Northwest of the country will experience 20% reduction in precipitation (Fig. 2 right panel).

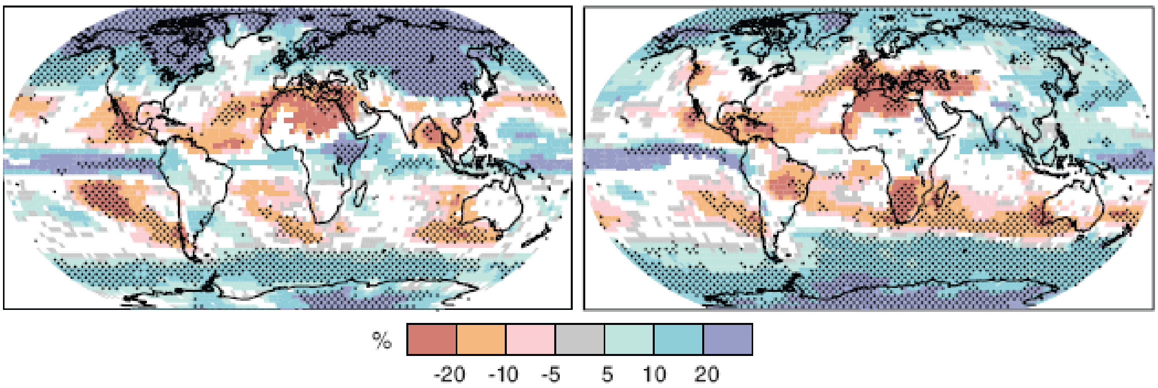

Fig. 2- Multi-model projected patterns of precipitation changes; Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (winter-left) precipitation 10% reduction in west of Iran and about 10% increase in west of Caspian Sea, and June to August (summer-right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. Precipitation more than 20% reduction in north and north-west of Iran, (Fig. 10.9, source: WGI Fig. SPM.7, IPCC, 2007).

Future climate projection for Asia sub regions

Projected changes in surface air temperature and precipitation for sub-regions of Asia under SRES A1FI (highest future emission trajectory) and B1 (lowest future emission trajectory) pathways for three time slices, namely 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2099) was provided by IPCC (Table 2) (Cruz *et al*., 2007). Astara study area is part of both Central Asia and also West Asia sub-regions (Table 2).

With comparison of two sub-regions of Central Asia and West Asia (Fig. 3), which both include and cover Astara region, it could be extracted, that temperature in both sub-regions and based on both scenarios, and in four seasons, and for all tree time slices will increase.

In general, amount of precipitation in West Asia will show more increment than Central Asia. Mean annual precipitation in West Asia will increase, but mean annual precipitation in Central Asia especially according to the scenario B1 will reduce (Table 2 and Fig. 3). Winter precipitation in West Asia will reduce while in Central Asia will increase. Spring precipitation in both sub-regions will reduce. According to the projections precipitation in summer and autumn seasons in West Asia will increase, but summer precipitation in Central Asia will reduce and precipitation in autumn season slightly will increase.

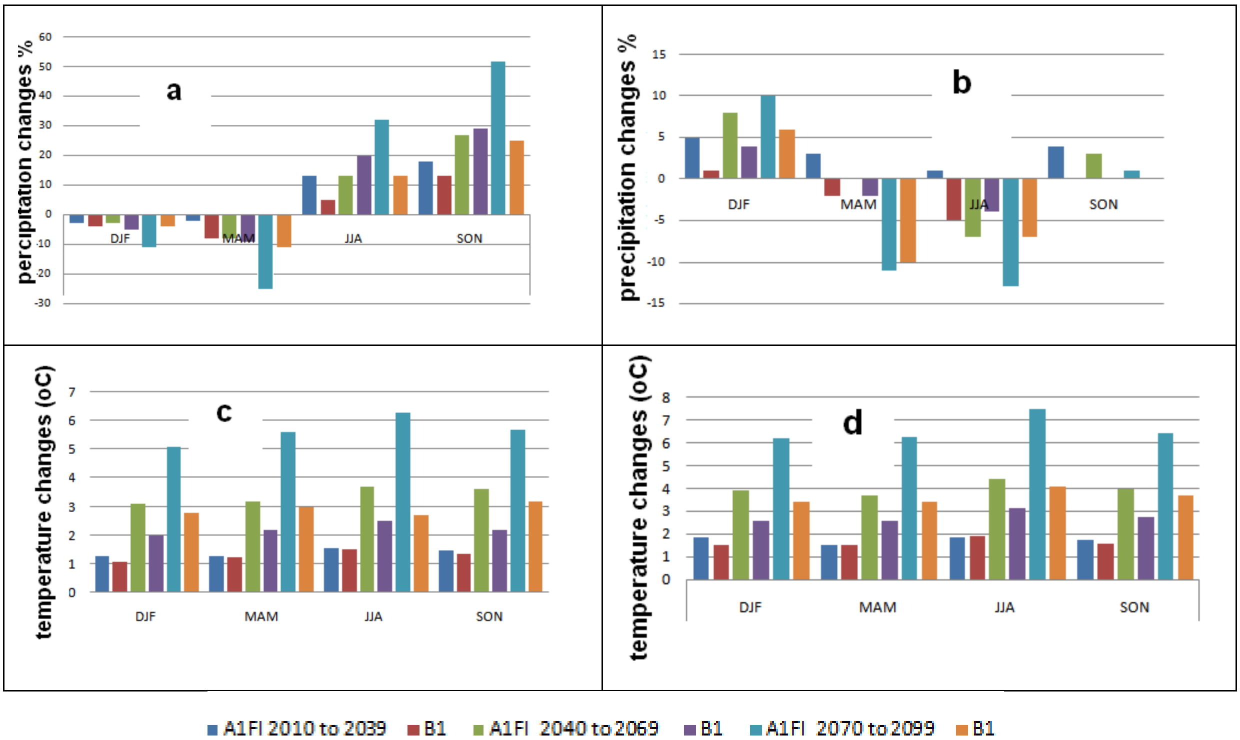

Fig. 3- Projected changes in precipitation (top graphs[1]) and surface air temperature (bottom graphs) for West Asia (left graphs) and Central Asia (right graphs) sub-regions projected under SRES A1FI (highest future emission trajectory) and B1 (lowest future emission trajectory) pathways for three time slices, (source: table 10.5, Cruz *et al.*, 2007). in four seasons (DJF, MAM, JJA, SON) in three 30 years periods namely 2010-2039, 2040-2069 and 2070-2099, [1] Graphs produced by author according to the IPCC data

Table 2- Yearly mean (four seasons) of projected changes in surface air temperature (°C) and precipitation (%) for west and central sub-regions of Asia under SRES A1FI (highest future emission trajectory) and B1 (lowest future emission trajectory) pathways for three time slices, namely 2020s, 2050s and 2080s (source: Table 10.5, Cruz *et al.*, 2007).

Sub-region	Yearly mean (4 seasons)	2010-2039				2040-2069				2070-2099			
		Preci. (%)		Temp. (°C)		Preci. (%)		Temp. (°C)		Preci. (%)		Temp. (°C)	
scenarios		A_1F_I	B_1	A_1F_I	B_1	A_1F_I	B_1	A_1F_I	B_1	A_1F_I	B_1	A_1F_I	B_1
West Asia	Mean	6.5	1.5	1.4	1.3	7.3	8.7	3.4	2.2	12	5.8	5.7	2.9
Central Asia	Mean	3.3	(-) 1.5	1.7	1.6	1	(-) 0.5	4.0	2.8	(-) 3.3	(-) 2.8	6.6	3.7

Past climate changes in Middle East

According to the results obtained from a study with using data for 52 stations in 15 countries including Iran, temperature increased significantly during 1950 to 2003 (Zhang, *et al.*, 2005). Also some changes observed in the amount of precipitation. Following the IPCC report, in West Asia and Middle East including Iran, according to the climatology stations data, from 1951 to 2003 because of increase of temperature the number of frozen days reduced significantly.

Climate Projections in Middle East

Future projections for precipitation (%) and temperature ($^{\circ}$C) changes has been provided by IPCC for the Middle East region for three time slices, namely 2010-2039, 2040-2069 and 2070-2099. Temperature for all four season according to the different scenarios will increase up to 2 degrees Celsius (Fig. 4). Possible precipitation changes could be summarized as follow:

In spring: More reduction of precipitation will occur. In summer: According to some

scenarios reduction and according to some others increase will occur. In autumn: Mostly increase will occur. In winter: Not too much change will be observed.
It can be concluded that, in Middle East according to the projections, in general precipitation will decrease and amount of precipitation will shift from the spring to the autumn (Fig. 4).

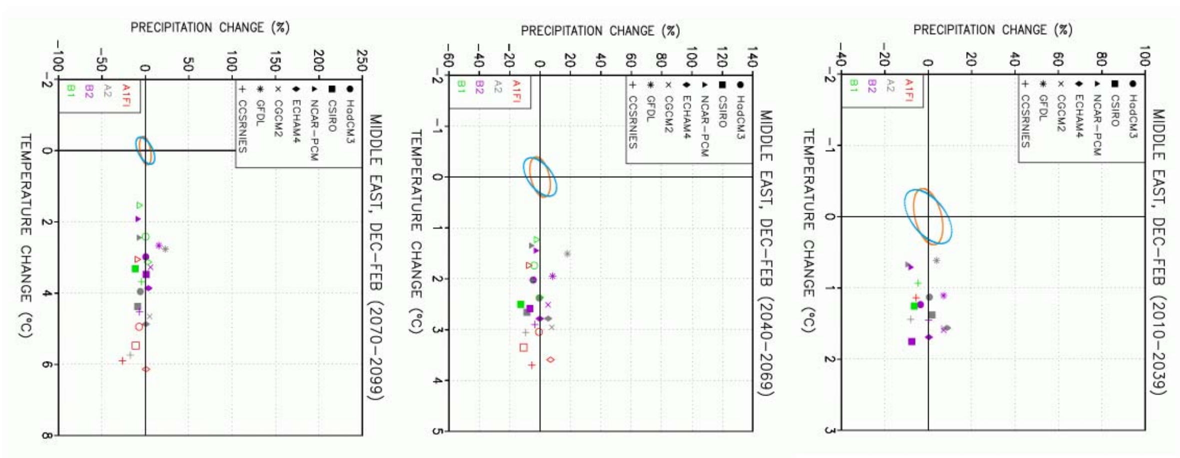

Fig. 4- Future projection of Precipitations (%) and temperature (°C) changes in Middle East, for Dec.-Feb. in 2010-2039, 2040-2069 and 2070-2099 (source: IPCC, 2007; Tim Carter, IPCC projections expert).

Past climate changes in Iran

According to the recorded data in synoptic stations in IRIMO significant increase in minimum, maximum and mean of temperature in most regions observed. In some region like Central, North West, North East of Iran significant decrease observed. In some station increasing pattern and in some other decreasing pattern for precipitation observed.

In Hyrcanian forest region in southern part of Caspian Sea temperature pattern most often increased in last half century (Jafari, 2008a) and precipitation pattern in the same region mostly showed a decreasing pattern in the same period (Table 3) (Jafari, 2008a).

Table 3- Trend of temperature and precipitation changes in last fifty years of Caspian region (Jafari, 2008a):

Station (years)	Trend of temperature and precipitation in last fifty years					
	Precipitation change (mm)		Temperature change (°C)			
			Minimum	Maximum		Mean
	Increase	Decrease	Increase	Increase	Decrease	Increase
Rasht (49)	56.4		2.45	0.08		1.28
Anzali (54)		509.4	2.10		1.18	0.40
Babolsar (54)	184.6		1.80	1.10		1.44
Gorgan (53)		55.6	0.11	0.31		0.09

Changes in temperature and precipitation patterns could cause climate conditions change and have impacts on forests, rangelands and deserts ecosystems (Jafari, 2008a).

Past climate changes in Astara

Past climate condition in the region analyzed by consideration of main climatic factors such as temperature and precipitation in synoptic and climatology stations. Also parameters like humidity and wind fluctuation were investigated. Climatology and synoptic stations data were for a time period of 40 and 18 years respectively.

Past conditions of precipitation in Astara with annual changes were studied, (1261.7 mm mean of 40 years of climatology and 1378.81 mm mean of 18 synoptic stations), monthly distribution (Fig. 5a), and seasonal (Fig. 5b), are presented in Fig. 5. Trend of precipitation changes in Astara has an increasing rate.

In Fig. 6, past changes in temperature pattern in two climatology (mean of 15.09°C in climatology and 15.02°C in synoptic stations) (Fig. 6a) are presented. Mean annual daily temperature the same as mean annual minimum temperature has an increasing pattern, while mean annual maximum temperature has a decreasing trend. With attention to the differences of elevation between two stations, small different of trends are interesting. Standard deviation of mean daily average (monthly) temperature in Astara climatology station showed that, temperature fluctuation in cold months in the region are much higher than warm months (Fig. 6a and b).

Mean annual changes in relative humidity in climatology station, 1961-2000, and in synoptic station, 1986-2003, were studied, and relative humidity in 03, 09, and 15 hours in climatology station, 1961-2000, is considered. Relative humidity changes in different hours had decreasing trends. Wind speed also in the same period showed decreasing patterns.

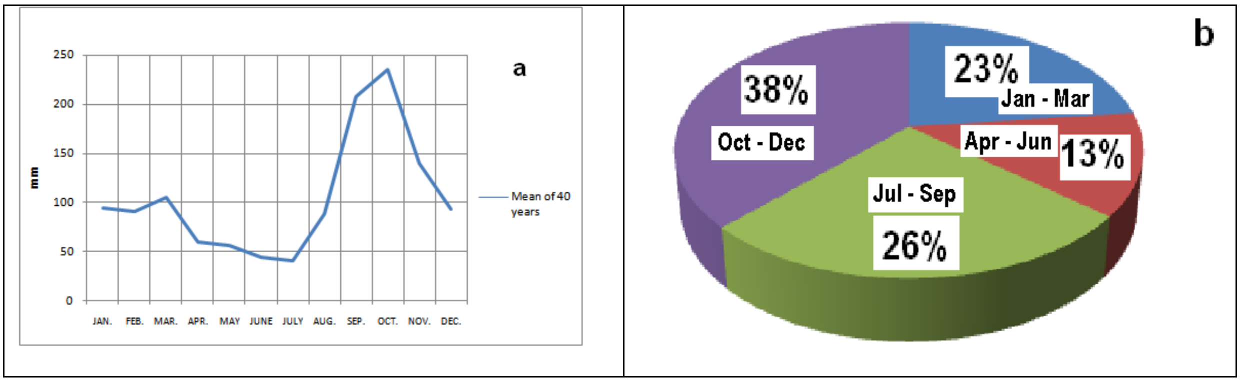

Fig. 5: Past changes of precipitation in Astara with monthly and seasonal distribution;
a) Mean of 40 years of monthly precipitation in Astara climatology station, 1961 -2000
b) Mean of 40 years of seasonal distribution of precipitation in Astara climatology station, 1961 -2000

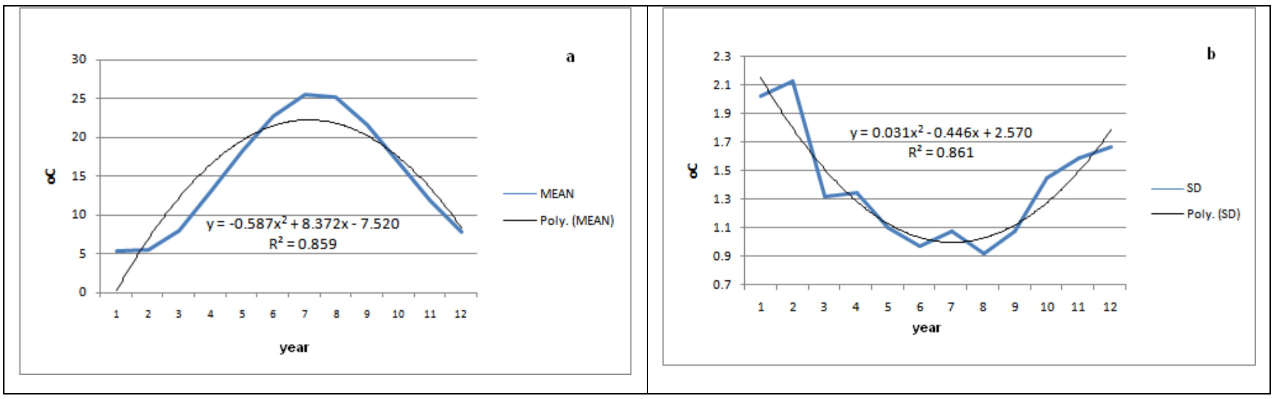

Fig. 6- Past changes of temperature in Astara;
a) Mean of daily average (monthly) temperature in Astara climatology station, 1961-2000
b) Standard deviation of mean of daily average (monthly) temperature in Astara climatology station, 1961-2000

Investigation on climate change projections in Astara and Ardebil

Based on IPCC data and models in global scale and national data and information, downscaling maps in national and regional scales (Fig. 7) produced (CC, IRIMO, 2007). National and regional climate projections have some agreement and disagreement with global, continental region and sub-regions projections.

According to the downscaled outcome maps, regional distribution of mean precipitation in future (2010-2039) comparing with the past (1976-2005), Astara region between 1 to 8.7 millimetres (mean of +4.85 mm) will increase (will reach to 1265.02 mm according to the climatology and 1383.61 mm according to the synoptic stations). While in near western part of Astara in the way to Ardebil, a small area will face with reduction of 5.8 to 23.3 mm (mean of -14.55 mm) rainfall (Fig. 7-right panel).

Mean precipitation of Guilan province for the time slice of 1976-2005 was about 1569.9 mm and projected for the period of 2010-2039 precipitation will increased by 10.63 % (amount of +167 mm) and will reach to 1736.9 mm.

Based on the same results, projections for future, the number of wet days in Astara region between 0-3 days will reduce, but in the same climatic area (west Southern) will face with 1-7 days increase of wet days. Mean of dry days will increase between 4 to 9 days. Also temperature in study area of Astara between 0.3 to 0.5 °C (mean of +0.4°C) will increase (will reach to 15.49°C according to the climatology and 15.42°C according to the synoptic stations) (Fig. 7-left panel).

Mean temperature of Guilan province for the time slice of 1976-2005 was about 16.2°C and projected for the period of 2010-2039 temperature will increased by 1.3°C and will reach to 17.5°C. It is needed to be noted that: based on downscaling produced maps in national and regional scales for 1979-2005, Astara region is in a category with temperature of 9.1-12°C. While based upon my data calculation obtained from climatology and synoptic stations mean temperature is about 15.02°C. Probably this rose from using Ardebil synoptic station with mean of temperature of 9.1°C for downscaling program.

Based on the same results, projections for future, the number of hot days in Astara region between 5-10 days will increase, and the number of freezing days will decrease between 0 to 5 days.

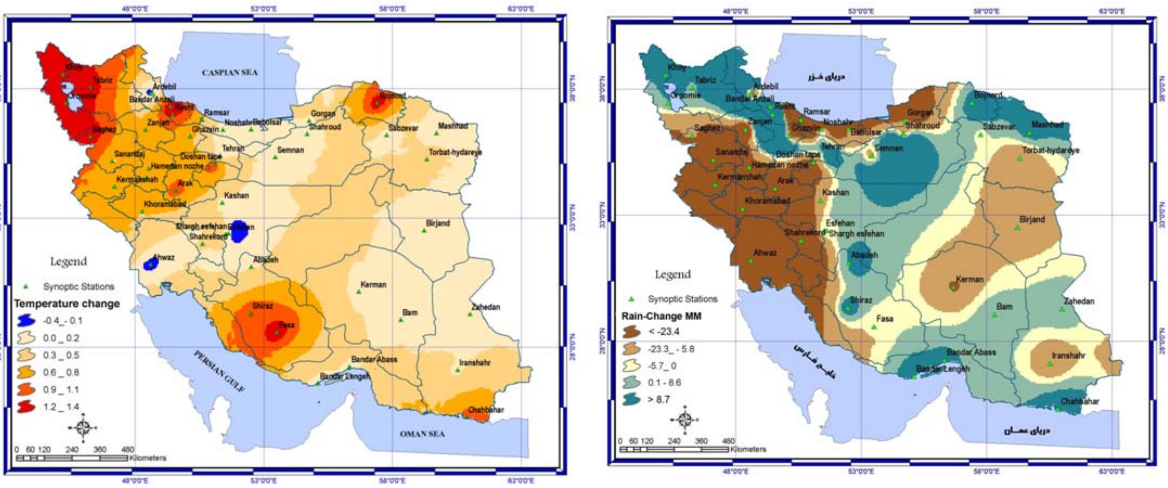

Fig. 7- Mean different distribution of temperature (left) and precipitation (right) in 2010-2039 compare with 1976-2005 according to the downscaling ECHO-G model (CC, IRIMO, 2007).

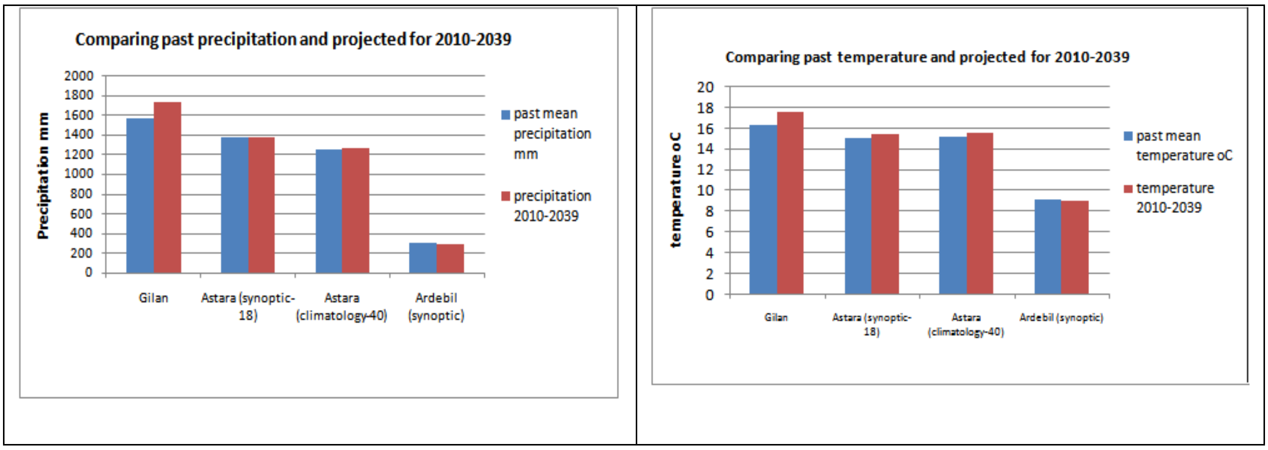

Fig. 8- Precipitation (left) and Temperature (right) changes in projected Period (2010-2039), comparing with time slice of (1976-2005), in Guilan province, Astara and Ardebil forests.

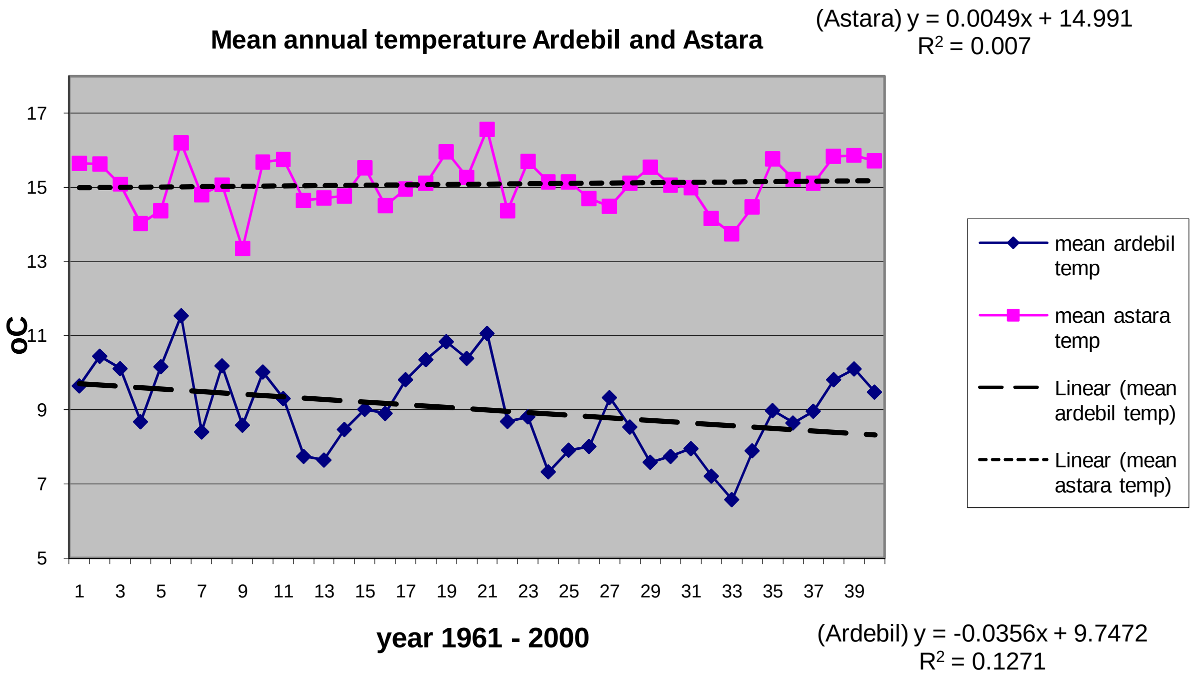

Fig. 9- Mean annual temperature in Ardebil and Astara stations

Climate conditions in Astara especial forest ecosystem (district 1)

For assessment of past climatic conditions of Astara region data from climatology and synoptic stations were considered (Tables 1 and Figs 5 & 6). To analysis of higher elevation changes, data from nearest station of Ardebil has been used. Ardebil station which is in high mountain in the west part of Astara, despite of difference in elevation (1325 m) which cause difference in temperature (5.2-8.3°C), have a good correlation in trend of temperature changes (Fig. 9). A detail of stations' characteristics is presented in Table 1.

In forty years ago in Astara region with each 252.95 m going upward, temperature was reducing by 1°C. At the year of 2000, because of increasing trend of temperature in Astara and decreasing trend in Ardebil with changing elevation of 193.04 m temperature will reduce by 1°C .

To this extend, can be conclude that main difference in climatic conditions in Caspian region raise form differences of the amount of precipitation, and temperature has a secondary effect.

Geographical situation in Astara district

Astara district is situated on western part of Albourz Range Mountain, with North-South direction. Therefore, forest covers are on West-East slops. This region is among those limited areas which from West are affected from Mediterranean (European) climate and from east north from Caspian currents.

Forest conditions and topography of Astara district

Total area of Astara district is about 22481.25 hectares including 18328.13 ha forests (total Guilan province 511306 ha), 545.31 ha cool condition rangelands (total Guilan province 467167 ha), and 3607.81 ha of farmlands and villages areas. Sixty percent of forest natural regeneration is from seed sources and 40% from seeds and copies. Details of forest information obtained from "Integrated Plan of Northern Forest, Primary Phase", studied and prepared by Technical Forestry Bureau in 1987 (TFB, 1987). Astara forest canopy classification according to the volume is from less than 100 to more than 350 m^3/ha. Astara, land classification of forest area according to the volume per hectare is about 85.92 up to 350 m^3/ha and about 14.07% with more than 350 m^3/ha. Mean volume per hectare is about 157.17 ± 8.8 (m^3).

Results

Precipitation changes

Last forty years of recorded climatology station's data showed increasing trends in

Astara total annual precipitation. Seasonal distributions of rainfall in last forty years are: fall (°Ct., Nov. and Dec.) 38%, summer 26%, winter 23% and spring 13% (Fig. 5 b). It means two seasons of autumn and summer received main percentage (64%) of annual precipitation. Warm seasons (summer and spring) received 39% of annual precipitation while cool season (autumn and winter) received 61%. In above mentioned time slice October received maximum (240 mm) and July minimum (40 mm) amount of rainfalls (Fig. 5a).

Temperature changes

Based on recorded data in climatology station, in Astara during last forty years differences of daily maximum and minimum of temperature as a 2^{nd} degree curve first showed increasing and then decreasing patterns. Trend on linear pattern showed a little decrease.

Trend of average daily mean temperature (monthly), showed increasing from January, and in July-August reach to its warmest position and then decline to minimum amount in December (Fig. 6a). Data approved that temperature fluctuation changes in cold months are greater than warm months. Standard deviation (SD) of temperature in cold months is about 2°°C and in warm months about 1°C (Fig. 6b). Changes in daily mean temperature (annual) in Astara station in last forty years as linear and 2^{nd} degree curves trends showed increasing patterns. According to the recorded data, mean of annual minimum temperature in cold month (January), warm month (July) and annul mean had increasing trends. Mean of annual maximum temperature in warm month (July), slightly in cold month (January), and for annul mean had decreasing trends. The reason of decreasing trend of differences of maximum and minimum temperature can be seen here. Hot days which started from May, continue up to October and reach its maximum values in July-August showed a decreasing trend both in linear and 2^{nd} degree curves. According to the data recorded in the synoptic station, mean annual temperature, January and July temperature, had increasing patterns in last 18 years.

Freezing days which started from November, continue to May next year, and reach its maximum values in January and February presented decreasing trend both in linear and 2^{nd} degree curves.

Temperature changes recorded for 18 years in synoptic station for cold season (January), warm season (July) and annual mean are in a harmony with last 18 years of changes which recorded for 40 years in climatology station. This can be interpreted of high level of confidence for the precise data.

Other climatic factors changes

As consequence of changes in temperature and precipitation, other climatic factors also will change. Relative humidity in last forty years reduced. The relative humidity also in 03, 09 and 15 hours in the same time period reduced. The percentage of relative humidity from 03 hours comparing to 09 hours and from 09 to 15 reduced by about 4.81% and 5.93% respectively. It means the percentage of relative humidity from 03 to 15 hours reduced by 10.74% and the rate of reduction will increase from 03 to 15 hours. In last 18 years, wind speed showed a reducing trend. Change in wind pattern and its fluctuation were investigated elsewhere (Jafari, 2008b).

Discussion

As a fact which Iran is located on dry belt of earth and importance of its vegetation cover and forest ecosystems (Jafari, 1997), and also inadequate research on climate change (Cruz *et al*., 2007), consideration of past climatic changes and investigation on future climate projection have very important role in development programs. Even though, the changes in temperature and precipitation are consistent with the other factors (Hsu and Chen, 2002).

Assessment of all data, document and reports on the past climate changes in the region confirmed that, temperature in last half century increased (Table 4). Studies on the past temperature changes related to the Astara region in global, continental, national, and local levels do not have significant differences, except small variation in seasonal changes. Even though, temperature had a reducing trend in Ardebil region which is in the high mountains of Western part of Astara. Projections for future temperature changes in Astara are mainly documented for increasing temperature and its amount are different based on employed scenarios (Table 5). Elsewhere, research outcome showed that all the IPCC scenarios have similar patterns and only differ in amplitude (Boulanger *et al*, 2006). From time slices point of view, longer time will experience higher degrees of temperature changes. Astara is located in both Central Asia and West Asia sub-regions in IPCC assessments (Cruz *et al*., 2007). Based on the projection for Central Asia sub-region, the region will face with higher degrees of temperature changes, which this is not in the same line as national and local downscaled projections. Downscaled projections in local level prove that Guilan province as whole will have higher degree of temperature changes than Astara which is in the western part of the province, and going more westwards, which is mountainous area of Ardebil; this will change to reduction of temperature.

Precipitation trend in Middle East region decreased in last half century with some seasonal increase. Precipitation in Guilan province showed decreases (Anzali station) and increase (Rasht station) patterns of rainfall with seasonal changes. Astara experienced of increase of precipitation in last fifty years with some reduction in seasonal levels. Based on global projection with A1B scenario in time period of (2090-2099) Astara which is in the western part of Caspian Sea, in winter season despite of reduction of precipitation in west part of the country, will have 10% increase of rainfall, and in summer will face with 20% reduction of precipitation, which these are in the same line of IPCC projection for the Central Asia sub-region and against its projection for the West Asia sub-region (Table 5). Projections for Middle East region and downscaled projection in national and local levels are more or less in harmony with these projections.

It seems for future projection on precipitation changes in the Astara region it is possible to benefit of global, Central Asia sub-region, Middle East and downscaled national level projections.

Table 4- Comparison of past changes on Astara precipitation and temperature in different scales

Scale of study		Precipitation (past)	Temperature (past)
Global			1-2 °C increase (1970-2004)
Asia	West Asia		Increase (1951-2003)
Middle East		Decrease and increase	Increase (1951-2003)
National	Guilan	Decrease (Anzali) and increase (Rasht)	Increase
	Ardebil		Decrease
	Astara	Increase of mean (seasonal increase and decrease)	Increase

Table 5- Comparison of future projections changes on Astara precipitation and temperature in different scales

Scale of study		Precipitation (Projections)	Temperature (Projections)
Global		Winter (Dec. to Feb., scenario A1b) 90s (2090-2099) 10% reduction in west of country and increase of 10% in west of Caspian Sea Summer (June to August) 90s 20% in north and north west of the country	3 – 3.5°C increase in 90s (2090-2099, scenario A1B) 1 – 2°C increase in 20s (2020-2029, scenarios B1, A1B, A2) 4 – 5.5°C increase in 90s (2090-2099, scenarios B1, A1B, A2)
Asia	Central Asia	Reduction mean especially based on B1 From 0.5% to 3.25% (2070-2099, A1F1) reduction and from 1% to 3.25% (2010-2039, A1F1) increase Winter: increase Autumn: little increase Spring and summer: decrease	Increase (in 4 seasons, 2 scenarios - B1, A1F1-, 3 thirty years time slices from 2010 to 2099) From 1.6 to 6.6°C increase

Continued Table 5- Comparison of future projections changes on Astara precipitation and temperature in different scales

Scale of study		Precipitation (Projections)	Temperature (Projections)
	West Asia	Increase mean from 1.5% to 12% Winter and spring: reduction in 3 time slices (2010-2039, 2040-2069, 2070-2099), and 2 scenarios (A1F1, B1) Summer and autumn: more increase in 3 time slices and 2 scenarios	Increase (in 4 seasons, 2 scenarios - B1, A1F1-, 3 thirty years time slices from 2010 to 2099) From 1.2 to 5.6°C increase
Middle East		In general decrease and increase depend to the seasons and scenarios Spring: reduction Summer: reduction and increase depend to the scenarios Autumn: more increase Winter: not too much changes	Increase up to 2°C (2010-2039)
National	Guilan	Increase 10.6% (167 mm)	Increase 1.3°C (2010-2039)
	Ardebil	Reduction 5.2 % (2010-2039)	Decrease 0.1°C
	Astara	Increase (mean of 4.8 mm)	Increase 0.3 – 0.5°C (2010-2039)

References

Boulanger JP, Martinez F, Segura EC (2006) Projection of future climate change conditions using IPCC simulations, neural networks and Bayesian statistics. Part 1: Temperature mean state and seasonal cycle in South America. Climate Dynamics 27: 233-259.

CC, IRIMO, (2007) National Centre of Climatology, Islamic Republic of Iran Meteorological Organization, downscaling report.

Cruz RV, Harasawa H, Lal M, Wu S, Anokhin Y, Punsalmaa B, Honda Y, Jafari M, Li C, Huu Ninh N, (2007) Asia Climate Change 2007, In: Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ, Hanson CE (Eds.) Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Hsu HH, Chen CT (2002) Observed and projected climate change in Taiwan, Meteorology And Atmospheric Physics 79: 87-104.

IPCC (2007) Climate Change 2007, In: Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ, Hanson CE (Eds.) Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Jafari M (1997a) The Present Status of Forestry Research in I.R. Iran, in Four Articles on Forests, Technical Publication No. 176, Research Institute of Forests and Rangelands, Tehran Iran, pp 121.

Jafari M (1997b) Present status of afforestation research in I.R. Iran, in four articles on Forests, Technical Publication No. 176, Research Institute of Forests and Rangelands, Tehran Iran, pp 121.

Jafari M (1999) Forests and Forestry Research in I.R. of Iran, Journal of Tropical Forestry 44: 14-20.

Jafari M (2006) An overview on sustainable forest management (SFM) with an Introduction to monitoring and evaluation. Pouneh, Tehran, Iran.

Jafari M (2007a) Review on needfulness for plant ecophysiological study and investigation on climate change's effects on forest, rangeland and desert ecosystems, presented in Workshop: Climate Change in South-Eastern European Countries: Causes, Impacts, Solutions, 2627 March 2007, Orangerie, Burggarten, Graz, Austria.

Jafari M (2007b) Climate Change and IPCC Assessments (Abstract of Keynote Lecture of the Symposium), in The Final Report of ICCAP, The Research Project on the Impact of Climate Changes on Agricultural Production System in Arid Areas, March 2007, ICCAP

Publication 10-Japan, ISBN 4-902325-09-8, pp 315-317.

Jafari M (2008a) Investigation and analysis of climate change factors in Caspian Zone forests for last fifty years, Iranian Journal of Forest and Poplar Research 16: 314-326.

Jafari M (2008b) Thunder and storm fluctuations in the Caspian region over the last half century, Iranian Journal of Forest and Poplar Research 16: 583-598.

MacCracken MC, Barron EJ, Easterling DR, Felzer BS, Karl TR (2003) Climate change scenarios for the US National Assessment, Bulletin of The American Meteorological Society DOI: 10.1175/BAMS-84-12-1711

Okada M, Toshichika I, Motoki N, Masayuki Y (2009) Mesh Climate Change Data of Japan Ver. 2 for Climate Change Impact Assessments Under IPCC SRES A1B and A2, Journal of Agricultural Meteorology 65: 97-109.

TFB (1987) Technical Forestry Bureau (TFB) "Integrated Plan of Northern Forest, Primary Phase", vol.1, Districts 1, 2 and 3, Technical Forestry Bureau (TFB), Forests, Ranges and Watershed management Organization (FRWO), Ministry of Jihad -e- Agriculture.

Wang JF, Zhang XB (2008) Downscaling and projection of winter extreme daily precipitation over North America. Journal of Climate 21: 923-937.

Zhang XB, Aguilar E, Sensoy S, Melkonyan H, Tagiyeva U, Ahmed N, Kutaladze N, Rahimzadeh F, Taghipour A, Hantosh TH, Albert P, Semawi M, Ali MK, Al-Shabibi MHS, Al-Oulan Z, Zatari T, Khelet IA, Hamoud S, Sagir R, Demircan M, Eken M, Adiguzel M, Alexander L, Peterson TC, Wallis T (2005) Trends in Middle East climate extreme indices from 1950 to 2003. Journal of Geophysical Research-Atmospheres 110: D22104.