ENVIRONMENTAL PROBLEMS

Vol. 5, No. 3, 2020

AN INVESTIGATION OF THE CLIMATE CHANGE IMPACTS ON THE WATER RESOURCES IN IRAN

Nima Norouzi

Research Associate, Department of energy engineering and physics,
Amirkabir university of technology (Tehran polytechnic),
424, Hafez Avenue, PO. Box 15875-4413, Iran,
nima1376@aut.ac.ir

https://doi.org/10.23939/ep2020.03.149

Received: 28.05.2020

Abstract. Climate change may be defined as a change in the timing of weather conditions over a period of time. In this paper, relying on IPCC scenarios to investigate the effects of climate change on water resources.

Key words: Climate change, water resources, Scenario planning, hydrological cycle, drought

1. Introduction

Climate change and widespread fluctuations in the overall climate of the region, which is now considered to be part of global warming. Climate change is one of the biggest environmental challenges in the world today. Rising world temperatures that climate patterns can change sea levels and climate change on the eve of the consequences of climate change causes uneven distribution of rainfall in water resources. Water resources in the Middle East are no exception to this rule, and the lack of water supply in the future will face successive droughts, and the growing demand for water as well as the widespread challenge of water scarcity in the region, especially in Iran is one of the most important issues of the Iranian governance system in the late 21st century. According to estimates of the world bank, the future of the region will be warmer and drier, and coastal countries such as Qatar and Kuwait will be destroyed. According to the FAO, in more than 80 percent of models of estimation of climate change, rainfall in the region is reduced by more than 40 mm per year [1]. Rainwater resources are provided by reducing the danger zone. (Fig. 1) shows the situation of the Middle East countries in the (IPCC) report [2]. At an average rainfall of 240 mm per year, which is a small amount and its heterogeneous spatial distribution (28 % of the country has an annual rainfall of less than 100 mm). Every year, 70 % of 415 billion cubic meters that fall in Iran evaporates. On the other hand, the average annual rainfall in the world is more diverse than Iran, which is 833 mm, while in some parts, it reaches 50 mm.

Several models, such as the US Standard Atmospheric Administration (USSA), the Goodward Space Studies Institute (GISS), the National Center for Atmospheric Research (NCAR), and the Geophysical Fluid Dynamics Laboratory (GFDL), have been developed by the US Academy of Sciences, Canada, the United Kingdom, and Australia and Russia to predict climate change. These models are based on meteorological information to determine the temperature and change of carbon dioxide, as shown in Fig. 2. It can be seen that the temperature shows a slight cooling trend while CO_2 is steadily increasing. However, it should be noted that in a long-term warming process, there have been short cooling periods over the past few decades. The average global temperature has risen by about 0.8 degrees Celsius (1.4 degrees Fahrenheit) since 1880, according to a continuous temperature analysis conducted by scientists at NASA's Goddard Institute for Space Studies (GISS) two-thirds of the warming has occurred since 1975, at a rate of approximately 0.15–0.20 °C per decade [3].

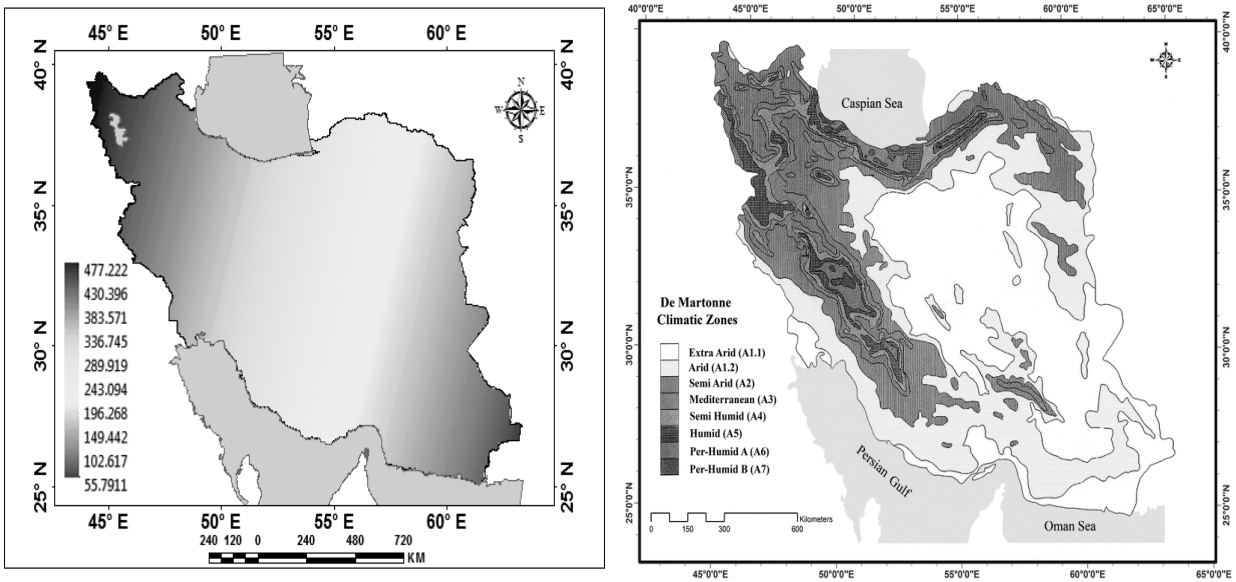

Fig. 1. Iranian topographic information about climate and water resources [2]

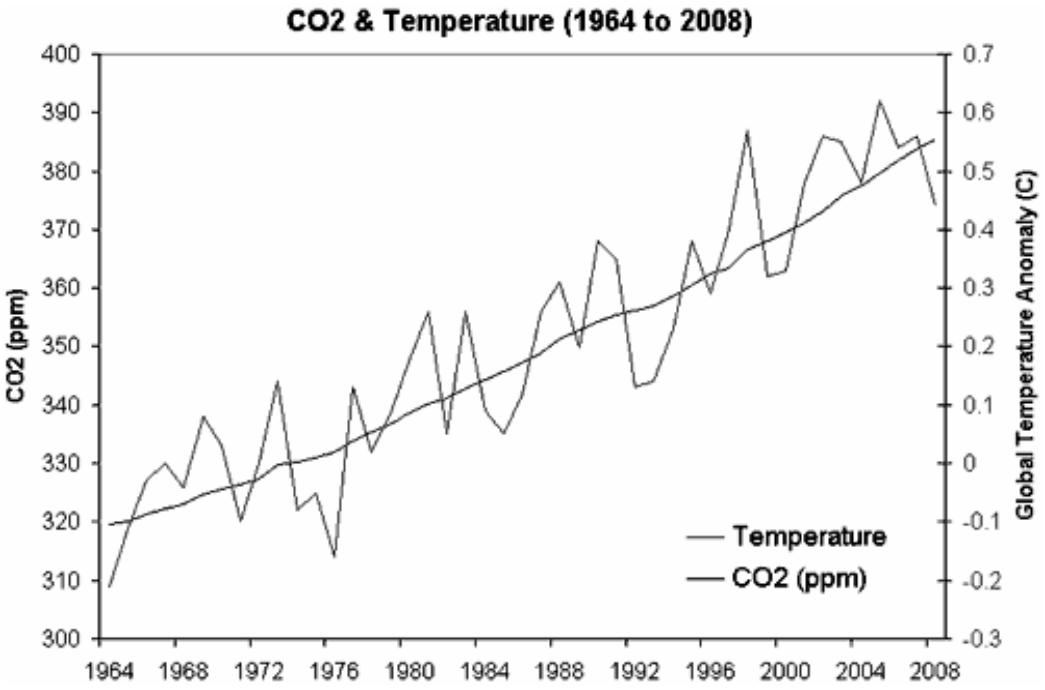

Fig. 2. Correlation between CO_2 concentration and temperature [3]

2. Method and the general theory

This study examines climate change and its impact on water resources in Iran. The vulnerability of water resources and sensitivity to climate change and to such challenges have been addressed by Arnell in recent years [3]. The quantity and quality of climate change affect water resources and the need for the water, agriculture, and drinking water industries. Due to the increase in average temperature in the land, evaporation increases, and the need for irrigation increases. It is often thought that this region has abundant water resources and has a perfect climate, and the consequences of climate change in this region will not be significant or negligible [4]. However, the past water resources in the region have been excessive due to various pressures and withdrawals. Any change in climate patterns that increases temperature and decreases rainfall increases the existing problems. Rainfall changes in wet seasons (from October to April), the model of small changes in average rainfall also showed local areas. At the same time, the temperature rises in all seasons. The average summer temperature has increased in the region [4].

3. Results and Discussion

Iran's geographical location is such that three different climatic conditions can be identified in its different regions (Iran Meteorological Organization 2014). the humid climate is prevalent in the coastal areas of the Caspian Sea with an average annual rainfall of 1600 mm. The semi-arid climate is observed in the mountainous regions of Zagros, with an average annual rainfall of 450 mm and the arid climate in deserts of the country with an average annual rainfall of 50 mm. Annual rainfall on the Caspian coast in northern Iran has brought wet forests, and desert areas of the country have the least annual rainfall. Of the average annual rainfall of 413 billion cubic meters (bcm), it is estimated that 71 % evaporate before reaching rivers. Total long-term renewable water resources are estimated at 130 bcm per year, of which about 80 bcm reaches surface runoff, and groundwater recharge is estimated at about 50 bcm per year. The average annual rainfall is estimated at 250 mm, from 50 mm in parts of the central water basin to more than 1600 mm in some coastal areas near the Caspian Sea (Rostam Afshar 1996). The average annual global rainfall is below 830 mm, which classifies Iran as an arid and semi-arid country[5].

It may be noted that due to climate change, heavy rains and floods are becoming more common. They are closely tied and are recognized as a threat around the world. Therefore, monitoring and evaluating how climate change has occurred in the past is crucial to activating the protection of people and important infrastructure. Table 1 shows the average monthly rainfall (mm) for data and temperature change for 30 years. June may be the warmest month of the year, with temperatures averaging 35.9 °C in January and the coldest month. The average temperatures vary during the year by 33.1 °C. The wettest month is February, with 43 mm of rainfall. Precipitation is the lowest in July, with an average of 2.8 mm. The difference in precipitation between the driest month and the wettest month is 40.2 mm. A recent study (Rostam Afshar and Fahmi 2012) shows the ability of the Fourier series to simulate long-term rainfall of up to 300 years, as an important finding in the rainfall forecast study. The analysis of the average monthly rainfall (mm) for 28-year data with simulated outputs in Table 2 shows that the annual rainfall of the country follows the trend of minimum rainfall from the simulated outputs, which is 43.36 [6]. Percentage of long historical time. Series. In addition, there is a 1-month distribution in rainfall distribution during long rainy seasons. It has also been found that the amount of rainfall in most parts of the country, especially in the western regions during the study period from 1977 to 2012, has decreased as shown in Fig. 3, somewhere Negative values indicate a decrease in rainfall [7].

According to [8], Figure 4 shows that the temperature increased from 1977 to 2012 by 1.1 °C. Parts of the Alborz region until 2050 are presented according to Fig. 4. It is worth mentioning that increasing the surface temperature will stimulate evaporation, precipitation, surface, and groundwater, and as a result, the quantity and quality of water resources.

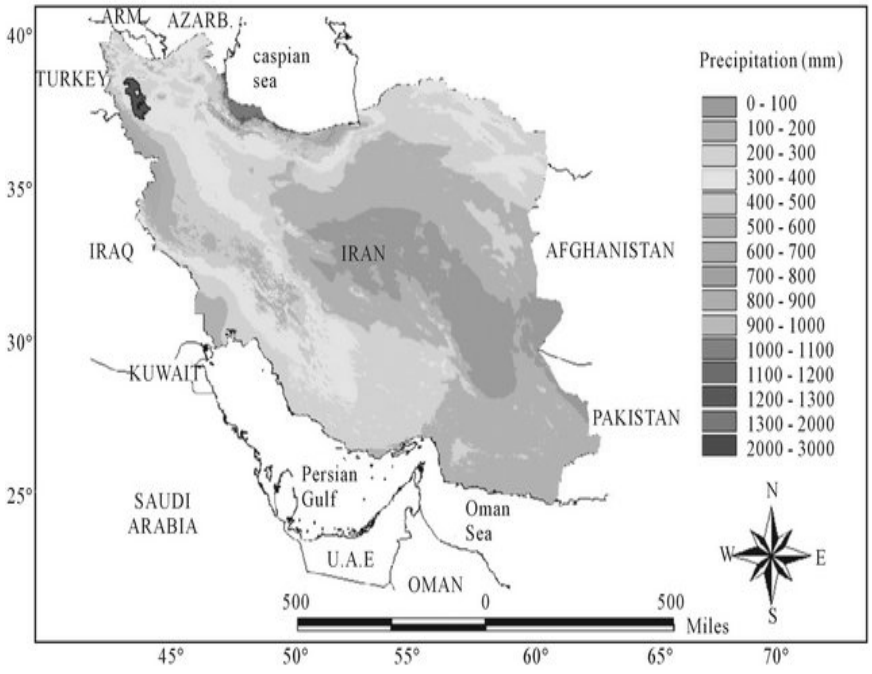

Fig. 3. Mean rainfall in Iranian regions [7]

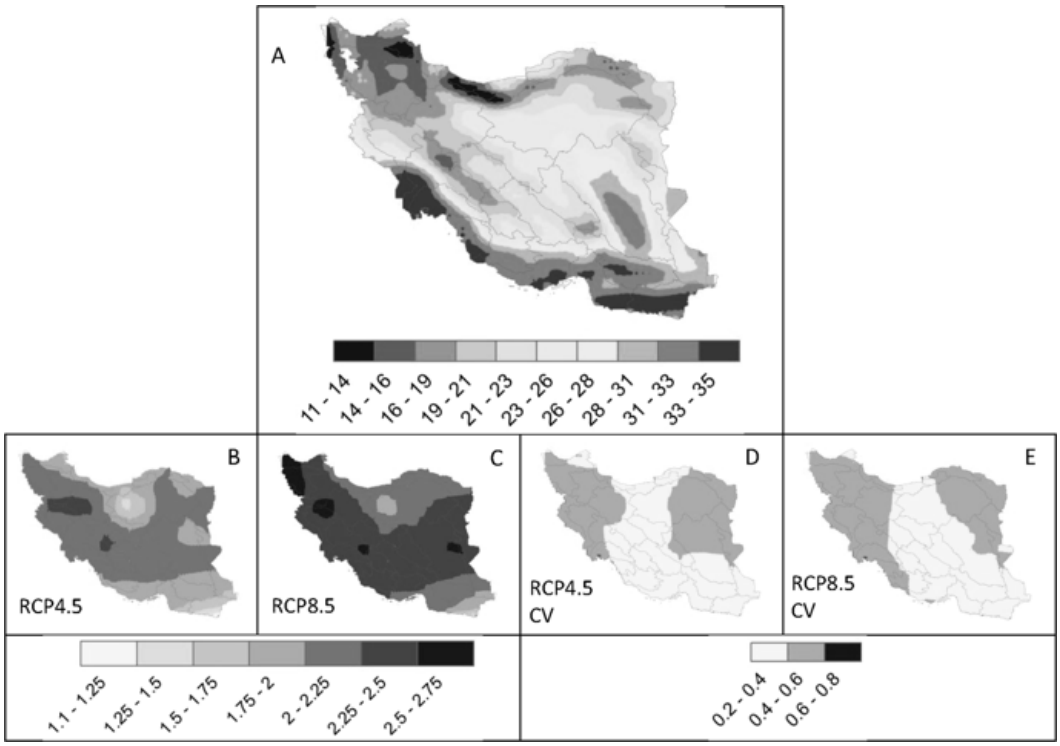

Fig. 4. Mean Temperature in Iranian regions [7]

Table 1

Average monthly rainfall (mm) data and temperature variation (for 30 years)

Month	Ave. rainfall [mm]	Actual rainfall [mm]	Mean Temp. [C]
Oct	7.821	7.524	17.82
Nov	18.81	10.593	10.89
Dec	33.8283	10.296	5.346
Jan	39.402	26.829	2.772
Feb	42.57	19.602	5.049
Mar	40.095	0.99	9.405
Apr	33.957	0.99	14.949
May	22.473	0.99	20.988
Jun	6.138	0.99	35.541
Jul	2.772	0.99	29.007
Aug	3.267	0.99	28.314
Sep	4.554	0.99	24.156
Total	255.717	74.844	0.99

Table 2

Simulated rainfall (mm) data and temperature variation (for 300 years)

Status	total		percentage	
	5 months	12 months	5 months	12 months
Simulated				
30-year ave.	142.4313	255.717	0.99	0.99
Max	207.108	371.547	1.43946	1.438371
Mean	142.065	255.222	0.987426	0.98802
Min	61.875	110.88	0.430056	0.429264
Actual	74.844	–	0.520146	–

Examining possible changes in temperature, precipitation, solar radiation, and evaporation is important to assess the impact of climate change on water resources. As the temperature rises, more water evaporates in the

air. Hot weather can hold more water vapor, which can lead to severe rainstorms and cause major problems such as severe flooding. The rate of evaporation is about 2000 mm in Iran, which is almost three times the global average. In the analysis of evaporation data, it was observed that out of 600 evaporation stations, 54 % of the stations were affected by climate change from 1977 to 2012 there was a temperature increase of 1.1 °C. The temperature in most parts of the Alborz region will increase between 2 and 3 degrees Celsius by 2050. If the temperature rises to 2 °C and the total rainfall throughout the country (413 bcm) is kept constant, the potential evaporation increases by 6.7 %, which comes to 26.00 bcm and is equivalent to the capacity of the existing reservoirs [9].

The Franco-Rodier approach was used to assess flood intensity and is shown in Table 3. It may be observed that significant changes have been observed in the Franco-Rudier index, indicating an increase in river flooding in 54 % of all irrigation stations surveyed. In addition, flood analysis shows that the number of devastating floods has increased even if the average annual rainfall remains unchanged, which may be due to climate change. Analysis of the data shows that the annual runoff changes significantly with more runoff change in winter and less in spring by shifting parts of the spring runoff to the early peak of winter, which may be due to climate change phenomena. According to [10, 11], Figure 5 shows the four floods in the provinces of Ilam and Lorestan in western Iran in March 2019, which killed at least nine people. The results show that this flood trend will expand and intensify the flood.

The Caspian Sea is surrounded by five countries: Russia, Kazakhstan, Turkmenistan, Iran, and Azerbaijan. Four tidal measuring stations from which a historical time series has been observed to investigate the surface of the Caspian Sea. Analysis of the Caspian Sea surface shows that both the rise during 1926–1975 (about 3 m) and the fall during 1975–1995 (about 2 m) may be due to its infiltration process as a result of climate change as shown in Figure 6. Gianli shows that the water level in the Caspian Sea has decreased by nearly 7 cm per year from 1996 to 2015, or a total of about 1.5 m. The current level of the Caspian Sea is only about 1 meter from the historic low (28.5 meters) reached in the late 1970s [12].

Table 3

Flood index based on Franco-Rodier approach

Province	index (K)	Flood severity
Khuzestan	4.65	critical
Sistan and Balochestan	4.5	high
Gilan	4.4	high
Fars	4.3	medium
Kerman	4.25	medium
Khorasan	4.1	medium
Azerbaijan	3.95	low
Mazandaran	3.9	low

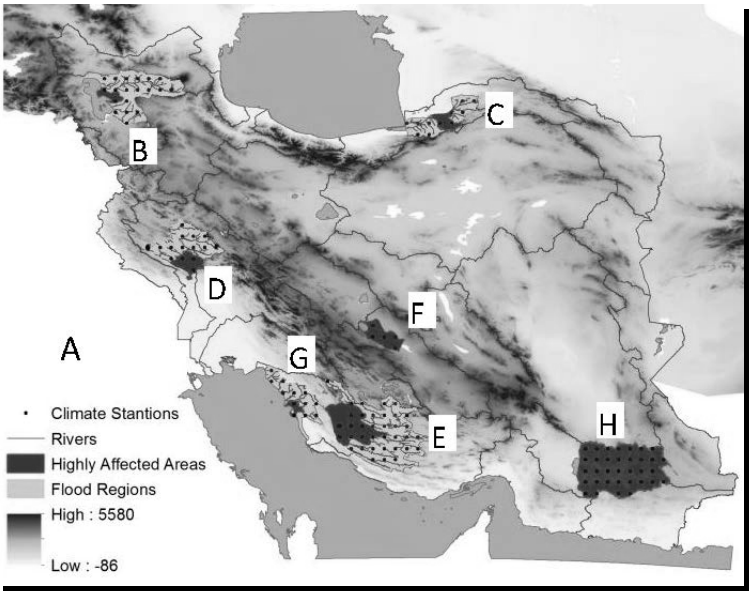

Fig. 5. chain flood events occurred in Iran year 2019

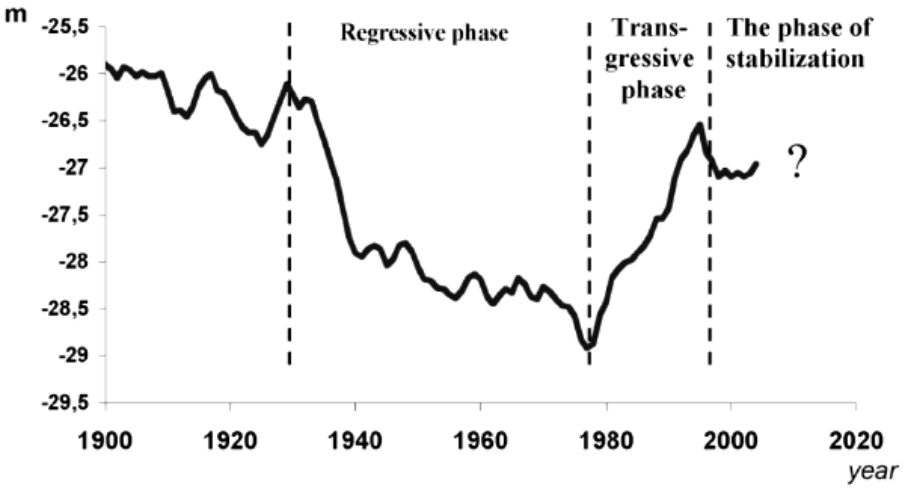

Fig. 6. Caspian Sea level during 2020–1900 [13]

Increased evaporation in the Caspian Sea is associated with an increase in surface air temperature. The average annual temperature of the Caspian Sea increased by about 1°C between the two time periods studied, 1979–1995 and 2015–1015. This increase in temperature is probably the result of climate change. Evaporation from global warming seems to be the main cause of the current sea level drop, and this decline is likely to continue as the Earth warms [14].

In the new century, the process to reach the sustainable development of water resources are facing the problem, the most important of which include the following:

1. Population growth increases the demand for drinking water, development, food, health, and other basic social and economic needs, While water resources are scarce [15].

2. Human activities are more different and less effective every day than before in terms of quantity and quality of natural resources.

3. Natural hazards associated with water, such as floods and droughts (climate change) that endanger human life [16].

Climate change and potential effects on rainfall distribution, runoff, and groundwater tables are fed, so you can not imagine that the future pattern of hydrological phenomena is the same as in the past [3]. A report on nature published by the World Wide Fund (WWF) in 2006 around the world, which is aimed to save water resources, states that rich countries are facing water shortages [17]. This warning about the water crisis caused by climate change predicts that by 2025, more than two-thirds of the world's population will face the water crisis. According to the World Water Council, 25 countries in the middle east are facing a water crisis now, with about 1.5 billion people (about 20 % of the world's population) deprived of access to safe drinking water, and by 2050 most countries will suffer from the water crisis. Global warming has severe damaging effects such as Climate change in the country due to various dimensions may include floods, droughts, outbreaks of diseases such as malaria, and ultimately effects on agriculture and the national economy. Norouzi said that it should be noted that all the consequences of water shortages are related to each other, and they can not be separated. According to the available statistics from 1901 to 1997, the situation of Iran's rainfall changes in the northern regions is predicted to decrease rainfall [6–9]. The change of precipitation regime in the central region of the southern slopes of the country from the Persian Gulf of Alborz to the area between the eastern slopes of the Zagros to the central regime is expected to increase rainfall. For the two hypothetical bands from north to south, east and west, a slight change in rainfall have been observed. The lead layer in the region to the north of Azerbaijan and the provinces of Ardabil, Khorasan, and the change of precipitation regime to a relative increase in rainfall is predicted. However, a review of climate data and measurements from the last decade shows that a complex trend in the climate system across the country is on the verge of development and the evaporation rate in some areas, the amount, intensity and type of precipitation, Snowmelt time, runoff amount and amounts are very impressive. What has recently become clear about the damage of climate change in winter and spring, which occurs in early winter, and snowmelt in a previous time and causes arid spring to have happened [18, 19].

Conclusion

The main effects of climate change-related to water resources are rising temperatures, shifts in precipitation

patterns, snow cover, and increasing the likelihood of floods and droughts. Climate change may significantly change the seasonal variation in river-flow changes. Higher temperatures will push the snow line upwards in mountainous regions, which reduces precipitation and causes a higher winter runoff. Moreover, earlier spring melts will lead to a shift in peak flow levels. As a result of the declining snow cover and decreasing glaciers, there will be less water to compensate for the low flow rates in summer. Climate change is a big challenge for the country and requires action on a large scale by the government. Many things can be done to reduce energy consumption and promote smart energy choices.

- To step up the use of clean energy like wind, wave, tidal, and solar power.
- To increase the energy efficiency of buildings, factories, and cars.
- To redesign the transport system by improving and expanding the use of public transport.
- To set up energy production more efficiently.
- To set up a low carbon economy with minimal use of fossil fuels.

Acknowledgment

I hereby thank all of the scientific supports of the Amirkabir university of technology from this paper.

References

[1] Zoljoodi M., Didevarasl, A.: Atmospheric and Climate Sciences, 2013, 3, 193. doi: 10.4236/acs.2013.32021.
[2] https://skepticalscience.com/print.php?n=59
[3] Khalili A., Rahimi J., Roozitalab M. et al.:: The Soils of Iran. World Soils Book Series. Springer, Cham, 2018.
[4] Kasimov N. S., Gennadiev A. N., Kasatenkova M. S. et al.: Earth Science Research, 2012, 1. doi:10.5539/esr.v1n2p262
[5] Fattahi E., Habibi M., Kouhi M.: J. Earth Sci Clim Change, 2015, 6, 319. doi: 10.4172/2157-7617.1000319
[6] Vaghefi, S.A., Keykhai, M., Jahanbakhshi, F. et al.: Sci Rep., 2019, 9, 1464.
https://doi.org/10.1038/s41598-018-38071-8
[7] Shadkam S., Ludwig F., van Oel P. et al.: J. Great Lakes Research, 2016, 42, 942. https://doi.org/10.1016/j.jglr.2016.07.033.
[8] Afshar N.R., Fahmi H.: Int. J. Energ Water Res., 2019, 3, 55. https://doi.org/10.1007/s42108-019-00013-z
[9] Francou J., Rodier J.A.: IASH-UNESCO-WMO, 1967, 1, 518.
[10] Iran Meteorological organization, Annual report, Tehran, 2014.
[11] Jianli C., Long-term Caspian sea level change, Austin, Texas: Center for Space Research, University of Texas at Austin, 2017.
[12] Khoshraftar R.: In Proceedings of the 5th WSEAS international conference on environment, ecosystems and development, Venice, Italy, 2006, 72.
[13] Rostam Afshar N., Water resources engineering, Tehran: Ministry of Culture and Islamic Guidance, 1996.
[14] Rostam Afshar N., Fahmi H.: J. Civil Engineering & Architecture, 2012, 6, 1258.
[15] IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations (also in Arabic, Chinese, French, Russin, and Spanish), 1995.
[16] FAO, Data from World Resources 1996-97, 1996.
[17] Teymori P., Gohardoust A.: J. Geol. Geosci, 2013, 2, 132. doi: 10.4172/2329-6755.1000132.
[18] Norouzi N., Zarazua de Rubens G., Choupanpiesheh S. et al.: Energy Research & Social Sci., 2020, 68, 101654. https://doi.org/10.1016/j.erss.2020.101654.
[19] Norouzi N., Kalantari G.: Water-Energy Nexus, 2020, 3, 72. https://doi.org/10.1016/j.wen.2020.05.005.