Original Research Paper

Urbanization Effect on Air Temperature in Iran's Zayanderud River Basin

[1]Ali Zahraei, [2]Sara Saadati, [3]Saeid Eslamian, [4]Kaveh Ostad-Ali-Askari and [5]Mohsen Ghane

[1]*Department of Irrigation and Drainage Engineering, College of Abureyhan, University of Tehran, Tehran, Iran*
[2]*Department of Natural Resources Engineering, Isfahan University of Technology, Isfahan, Iran*
[3]*Department of Water Engineering, Isfahan University of Technology, Isfahan, 8415683111, Iran*
[4]*Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran*
[5]*Civil Engineering Department, South Tehran Branch, Islamic Azad University, Tehran, Iran*

Abstract: Detection of urbanization effect to understand climate change is important. Urbanization effect on air temperature in Zayanderud river basin was evaluated using weather stations network. Map of the temperature trend was generated using full dataset and rural stations to visualize warming trends. A comparative analysis was carried out to estimate urban heat island effect. The result indicated that overall warming trend in the basin is 0.012°C year-1 and the contribution of urban warming to total temperature change was estimated to be 17%. Variation of urban warming throughout the basin was 0-0.016°C year-1. The centre of a basin with a large UHI effect by 0.006-0.016°C year-1 is more influenced by urbanization. Records of hemispheric mean temperatures from ground areas for the past 100 years prepare pivotal input to the argument over global warming. Contrary to precise apply of the basic station data in some of these collections of hemispheric temperature, there have been proposals that a ration of the 0.5°C warming seen on a century timescale may be related to urbanization affections-local warming caused by the effects of urban enlargement. The consequences display that the urbanization affection in two of the most widely used hemispheric data sets is, at most, an order of quantity less than the warming seen on a century timescale. The climatic alternations of the temperature are considered. Gridded temperature data are necessary to run ecological models at regional scales for climate impact studies and have been generated by spatially incorporating preceded values at synoptic stations.

Keywords: Urban Heat Island, Urbanization, Temperature Trend, Zayanderud River Basin, Iran

Introduction

Urbanization is a human activity that modifies the nature of the surface and atmospheric properties of a region. This phenomenon affects the surface energy budget, land–atmosphere interaction, hydrologic regimes, resulting in urban climate feature so-called Urban Heat Island (UHI) effect (Collier, 2006; Habete and Ferreira, 2016). More than half of the world's population is living in the cities and heat waves due to UHI can significantly affect human health. So, it is important to know the contribution of urbanization to the observed warming trends. Many studies were conducted on comparing rural

and urban warming and most of them pointed out a warmer climate in urban areas due to UHI effect (Yan *et al.*, 2010; Ren and Zhou, 2014). Jones *et al.* (2008) showed that temperatures in a suburb of London and Vienna increased relative to rural locations nearby in recent decades. Karl *et al.* (1988) studied the variation of temperature during 1901-1984 in urban and rural areas of United States and found that even small cities experienced the evident influence of urbanization on the temperature trend. Peterson *et al.* (1999) divided the 7280 stations of the world into rural, suburban and urban stations and, by analyzing the global mean temperature trend based on all of stations and the rural stations, they observed that the

rural stations are warming at 0.8°C (100yr)-1 while the increase of temperature for all stations was 0.92°C (100yr)-1. Ren *et al,* (2008) by comparative analysis of rural and urban stations investigated urbanization effect in north China. They found that the impact of urban warming is 0.11°C (10yr)-1 and the contribution of urban warming to total temperature changes is 37.9%. Hamdi *et al.* (2009) analyzed the effect of urbanization in the Brussels capital region, Belgium.

They estimated annual mean urban bias and contribution of UHI effect to overall warming trend by 0.61°C and 45% respectively. Chrysanthou *et al.* (2014) studied the effect of urbanization in Europe since1960. The result of this study indicated 1.45% (0.0026°C/10yr) of overall temperature trend (0.179°C/10yr) might explain by urbanization effect. Ebrahim *et al.* (2016) investigated the effect of urbanization on the daily temperature in Dubai during 1980-2012. They showed that the average temperature region recorded has been steadily increasing with a high reading of 47°C Celsius in 2012. Almazroui *et al.* (2013) investigated the possible effects of urbanization on the rise of air temperature in Saudi Arabia for the period 1981-2010 using population data. They indicated warming trend by 0.5-0.6°C/decade but suggested that the rise in air temperature is not likely due to urbanization changes. Saadatabadi and Bidokhti (2011) analyzed temperature trend in Tehran megapolis and Varamin (a small town in the southeast of Tehran) as a rural station to investigate urbanization effect. The result of the study indicated that temperature trend varies in response to the different rate of urbanization. Abbasnia *et al.* (2016) studied the variation of temperature trend in Esfahan megacity, Iran during 1980-2010 and indicated that constructed area and temperature has increased 23% and 0.06°C respectively. Also, they found the significant correlation between heart moralities and temperature trend.

Several studies have done to detect temperature trend in Iran and Zayanderud basin (Tabari and Hosseinzadeh-Talaee, 2011; Gandomkar, 2011; Ataei *et al.,* 2013; Ghasemi, 2015) but few researches (types of research) have been conducted on the effect of urbanization upon air temperature trend and it is unclear at present, how much effect the increased UHI magnitude has had on the long- term trends in Zayanderud basin.

Previous studies pointed out that increasing temperature in Zayanderud basin is an influential factor in imbalance between water consumptions and resources (Gohari *et al.,* 2013; Zareian *et al.,* 2015; Ahmadi *et al.,* 2015) and it is expected that the findings of this study contribute to getting better insight into sources of regional warming and more efficient management in the basin.

Data and Methods

Zayanderud River Basin

Zayanderud river basin with a semiarid climate is located in Isfahan province, central Iran (Fig. 1). The area of the basin is over 41,000 Km^2 with a population (of)over 5.3 million people where 70% of the population is living in the cities. The third megacity of Iran (Esfahan) located in the centre of the basin contains 50% of the basin's population.The Annual mean temperature of the basin is 13°C where east and west of the basin are the warmest and coldest areas (Fig. 2). Zayanderud dam in western basin stores runoff to supply urban, industrial, agricultural etc. demands.
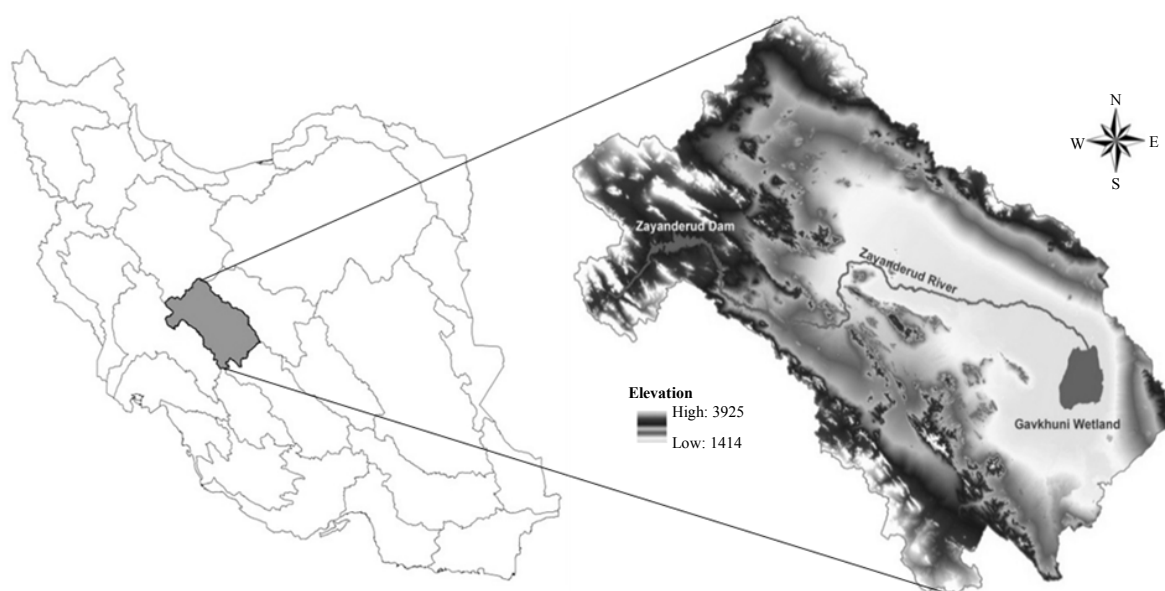

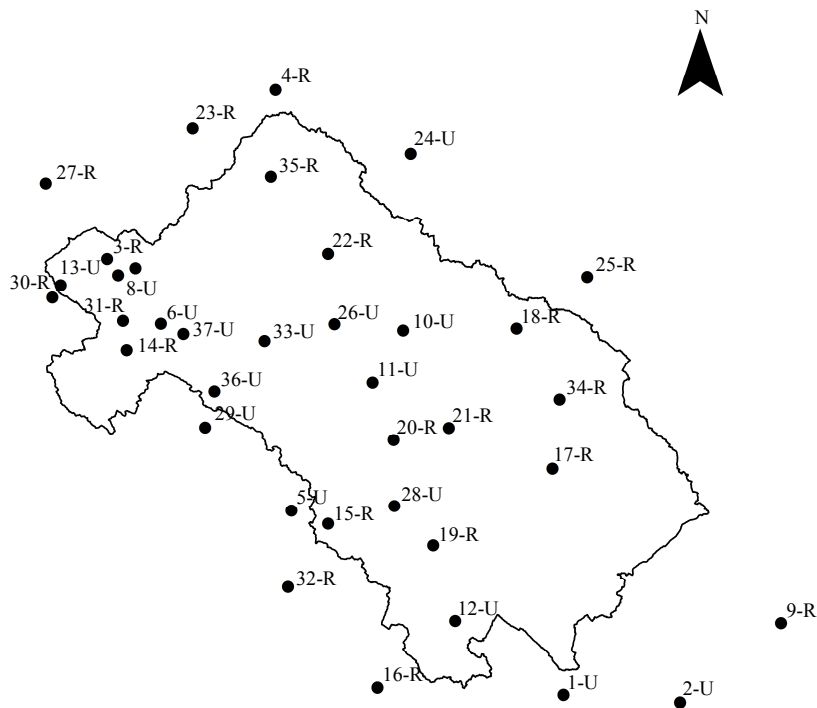**Fig. 1:** Location of Zayanderud river basin in Iran

Fig. 2: Variation of mean annual temperature in Zayanderud river basin (°C)
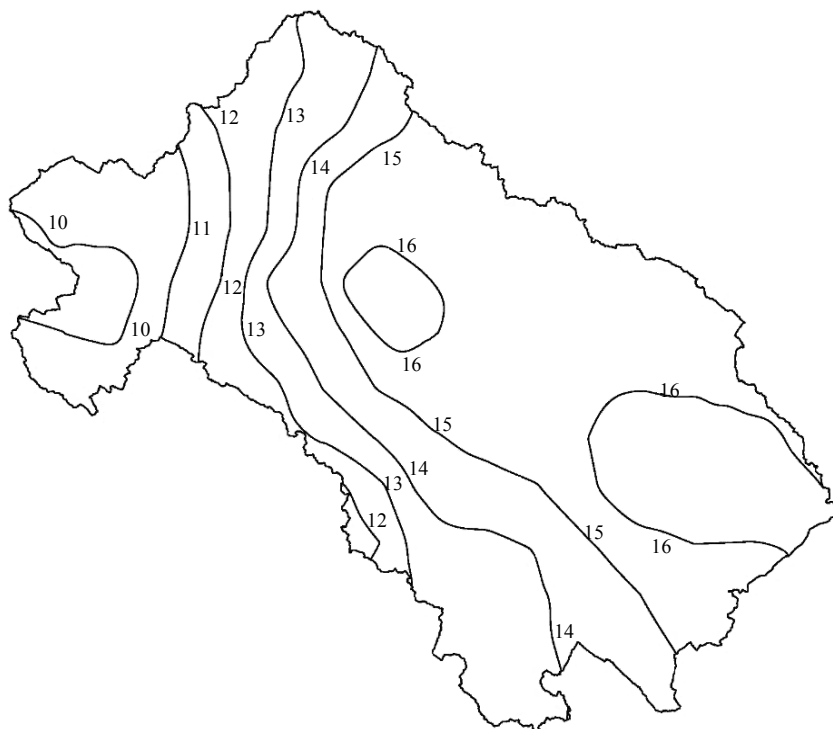

Fig. 3: The location of 37 weather stations. U: urban station, R: rural station, 1: Abade; 2: Abarkooh; 3: Badijan; 4: Barzuk; 5: Borujen; 6: Chadegan; 7: Damane; 8: Daran; 9: Dehshir; 10: Esfahan(east); 11: Esfahan(south); 12: Ezadkhast; 13: Fereydunshahr; 14: Ghalesharokh; 15: Hamgin; 16: Hanna; 17: Hasanabad; 18: Koohpaye; 19: Maghsudbeyk; 20: Mahyar; 21: Mohamadabad; 22: Murchekhort; 23: Mute; 24: Natanz; 25: Neysianak; 26: Palayeshgah; 27: Sarabhende; 28: Shahreza; 29: Shahrkord; 30: Sibak; 31: Singerd; 32: Solegan; 33: Tiran; 34: Varzane; 35: Vazvan; 36: Polezamankhan; 37: Zayanderud

Climatic Data

The monthly data during 1951-2010 were received from Iran meteorological organization and ministry of energy. There are 113 stations located in Zayanderud basin and around. Record lengths of these stations vary between 5 to 60 years. To enhance the validity of the results, the stations selected based on a large record of data (more than 30 years), continuity of the records and appropriate distribution throughout the basin (Ghahraman, 2006; Githui, 2009). On the basis of these criteria, 37 stations were selected for analysis in this study. All records started from the 1950s, 1960s, 1970s and 1980s to 2010. Among selected stations 21 stations, are located in the rural area and 16 stations are located in urban area. The location of stations is shown in Fig. 3. In this figure, urban and rural station is shown with "U" and "R", respectively. To avoid as much as possible, the influence of urbanization, rural stations were selected from villages, desert and mountaintop or towns with a population less than 5000 people (Ren *et al.*, 2008; Ren and Zhou, 2014). Monthly values of stations were averaged to obtain annual temperature for each station. To analysis, the homogeneity of the records, double-mass curve (Kohler, 1949) was used for each station. The results of double-mass curve showed that there are no obvious breakpoints in time series. There were a few gaps in selected stations. To fill these gaps, the recorded data in neighbour stations with high correlation were used.

Methodology

In this study, in order to detect the magnitude of temperature trends, Q Sen's slope estimator was applied (Sen, 1968). This method is commonly used for hydro-meteorological time series data. The slope estimates for N pairs of data are first calculated by:

$$Q_k = \frac{x_j - x_i}{j - i} \ for \ k = 1, 2, ..., N \tag{1}$$

where, x_j and x_i are the data values at times j and i ($j > i$) respectively. The median of these N values of Q_k is a Sen's estimator of slope:

$$Q_{med} = \begin{cases} Q_{\left[\frac{N+1}{2}\right]} & if \ N \ is \ odd \\ \dfrac{Q_{\left[\frac{N}{2}\right]} + Q_{\left[\frac{N+2}{2}\right]}}{2} & if \ N \ is \ even \end{cases} \tag{2}$$

The pre-whitened time series was used prior to applying Q Sen's slope estimator for removing the

influence of the serial correlation. In this study, at first serial correlation coefficient (r_1) is calculated for time series (x_1, x_2, x_3,……,x_n) with lag-1 according to Equation 3:

$$r_1 = \frac{\frac{1}{n-1} \sum_{i=1}^{n-1} \left(x_i - E\left(x_i\right) \right) \cdot \left(x_{i+1} - E\left(x_i\right) \right)}{\frac{1}{n} \sum_{i=1}^{n} \left(x_i - E\left(x_i\right) \right)^2} \tag{3}$$

$$E\left(x_i\right) = \frac{1}{n} \sum_{i=1}^{n} \left(x_i\right) \tag{4}$$

where, n is the number of observations and $E(x_i)$ is the mean of sample data. If the calculated r_1 is significant, the Sen's estimator will be used on 'pre-whitened' time series and if r_1 is not significant original time series can be used. (Tabari and Hosseinzadeh-Talaee, 2011; Gocic and Trajkovic, 2013; Islam, 2015).

After computing the magnitude of trends in stations, spatial distributions of trends over the basin was applied in Geographical Information Systems (GIS) and the raster map of the trend by all (rural-urban) stations and by rural stations were generated. Generated map by rural stations would be used as the reference for pre-urbanization and the map generated by all stations was considered as temperature changes of post-urbanization. To compute UHI effect, the values of rural-urban raster layer were subtracted from the values of rural (or reference) raster layer. (Peterson *et al.*, 1999; Ren *et al.*, 2008; Ren and Zhou, 2014). In this study, the spatial variation of trends was determined using the inverse-Distance-Weighted (IDW) interpolation technique. The IDW is a simple and widely used method for interpolating hydro-meteorological variables. This method that is based on the assumption that the values of the variables at a point to be predicted are similar to the values of nearby observation points (Pingale *et al.*, 2014). The formula of IDW (Bayazit *et al.*, 2016) is as follows:

$$W\left(d_i\right) = \frac{\frac{1}{d_i^p\left(x_i\right)}}{\sum_{i=1}^{n} \frac{1}{d_i^p\left(x_i\right)}} Z^*\left(x_0\right) \tag{5}$$

$$Z\left(x_i\right) = Z^*_{\left(x_i\right)} \left[\sum_{i=1}^{n} w\left(d_i\right) z\left(x_i\right) \right] \bigg/ \left[\sum_{i=1}^{n} w\left(d_i\right) \right] \tag{6}$$

where, $Z^*(x_0)$ shows predicted measure of x_0 point and $Z(x_i)$ indicates the measure of sample point at x_i point. The $w(d_i)$ is the weighting function and d_i is the distance from x_i to x_0. p is the power factor and n is the number of sample points.

Results and Discussion

Trends in stations

The summarized outputs of Q Sen's Slop estimator for mean annual temperature trend in 37 stations is presented in Table 1. In this table increasing and decreasing trends are shown with positive and negative signs respectively. According to the results, 32 out of 37 stations have an increasing trend, 4 stations have experienced decreasing trend and 1 station is without trend. Tiran station in the centre of the basin (33-U) and Ghalesharokh station in the west of basin (14-R) have the highest and the lowest trends.

Spatial Distribution of Trends

Figure 4 shows the distribution of temperature trend in Zayanderud basin after urbanization. The average temperature trend over the basin is 0.012°C year-1 and the highest and the lowest magnitude of trends are seen in central and western basin respectively. According to Ghasemi (2015), the average warming trend in Iran is 0.023°C year-1 and in comparison to the country as a whole, the warming trend over Zayanderud basin is generally weaker. In addition to urbanization effect, the reason for regional differences in the magnitude of warming over the basin may refer to physical geographic (e.g., topography, exposure), vegetation, land cover, land use, atmospheric circulation etc. Further investigation is needed to find the relation between trends and these factors. Figure 5 shows the distribution of temperature trend in Zayanderud basin before urbanization. The average of temperature trend before urbanization was 0.010°C year-1. According to the findings, the weakest pre-urbanization trends are seen in the west of the basin and stronger trends occurred in a southeastern basin.

UHI Effect

Figure 6 presents the difference between pre and post-urbanization warming (UHI effect) over the basin. The average UHI effect over the basin is 0.002°C year-1 so 17% of overall warming rate occurred in Zayanderud basin is caused by urban warming. According to information of ministry of the country, from 1970 to 2010, the number of cities in the basin increased from 31 to 77. In addition to changing the rural area to urban area, the already urbanized cities have expanded due to increasing population. Available information show in 1995, 2005 and 2010 urban population of the basin was 2.5, 3.2, 3.5 million people respectively. This urbanization process resulted in an increase of temperature over the basin. Sources of this warming refer to industrial processes, power plants, combustion process of vehicles, human metabolism and transfered heat from residential and commercial buildings. In addition, expansion of the cities from non-construction land to construction land with high

buildings (absorb more radiation) leads to rise temperature (Sailor and Lu, 2004; Yan *et al.*, 2016).

The centre of the basin experiences strongest UHI effect by 0.006-0.012°C year-1. Figure 7 shows the distribution of the cities in Zayanderud basin and around. 45 out of 77 cites of the basin are located in the central basin. These cities contain 70% of the basin's population. In addition, the majority of urbanized cites of the basin including Esfahan, Khomeinishahr, Najafabad, Zarinshahr, Fuladshahr, Shahinshahr and Mobarake are located in the centre of basin. It appears centre of the basin due to more concentration of anthropogenic activities experiences larger UHI effect. In the east and southeast of the basin cities are seen less than other part of the basin and most population are living in rural areas with a low living standard. In addition, in comparison with other zones of the basin in these areas, the cities are less urbanized. These issues perhaps are the reason for the lower UHI effect in this area.

Table 1: The magnitude of trends in urban and rural stations (C°/year)

| ID	Station	Trend slop
1-U	abade	+0.008
2-R	abarkooh	+0.011
3-R	badijan	+0.010
4-R	barzuk	+0.017
5-U	borujen	+0.006
6-U	chadegan	+0.013
7-R	damane	+0.006
8-U	daran	+0.010
9-R	dehshir	+0.007
10-U	esfahan(east)	+0.015
11-U	esfahan(south)	+0.018
12-U	ezadkhast	+0.015
13-U	fereydun shahr	+0.012
14-R	ghalesharokh	-0.009
15-R	hamgin	+0.002
16-R	hanna	+0.025
17-R	hasan abad	+0.022
18-R	koohpaye	+0.013
19-R	maghsudbeyk	+0.015
20-R	mahyar	+0.016
21-R	mohamad abad	+0.015
22-R	murchekhort	+0.017
23-R	mute	+0.015
24-U	natanz	+0.021
25-R	neysianak	+0.012
26-U	palayeshgah	+0.016
27-R	sarabhende	+0.019
28-U	shahreza	+0.010
29-U	shahrkord	-0.009
30-R	sibak	+0.003
31-R	singerd	-0.001
32-R	solegan	0.000
33-U	tiran	+0.027
34-R	varzane	+0.006
35-R	vazvan	-0.001
36-U	zamankhan	+0.006
37-U	zayanderud	+0.008
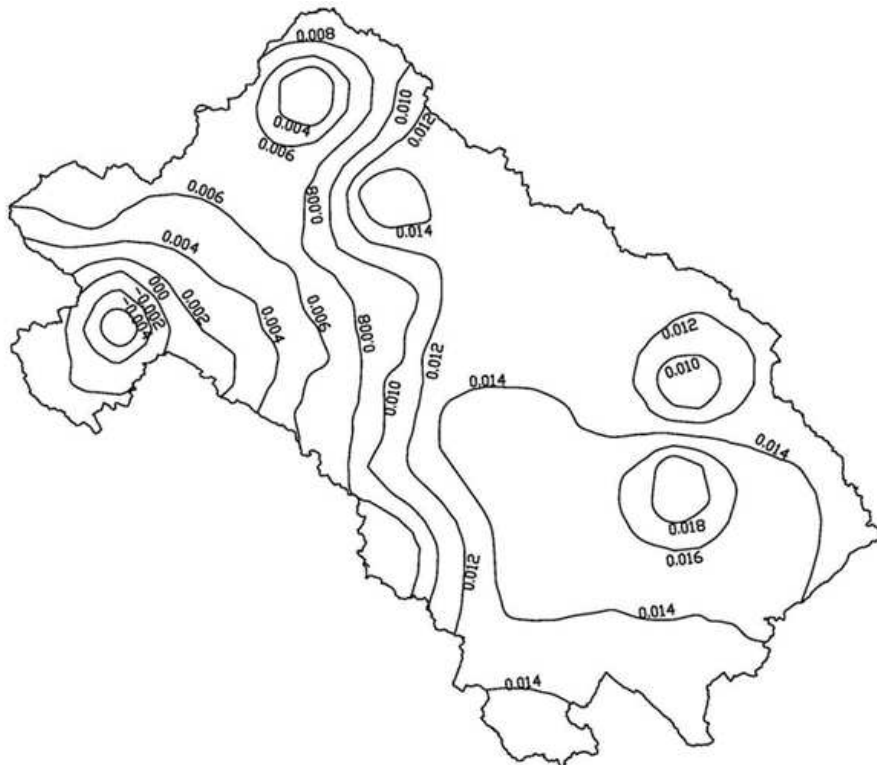
Fig. 4: The spatial distribution of the temperature trend in post-urbanization (°C year-1)

Fig. 5: The spatial distribution of the temperature trend in pre-urbanization (°C year-1)

685

Fig. 6: The difference in temperature trends between pre- and post-urbanization (UHI effect)
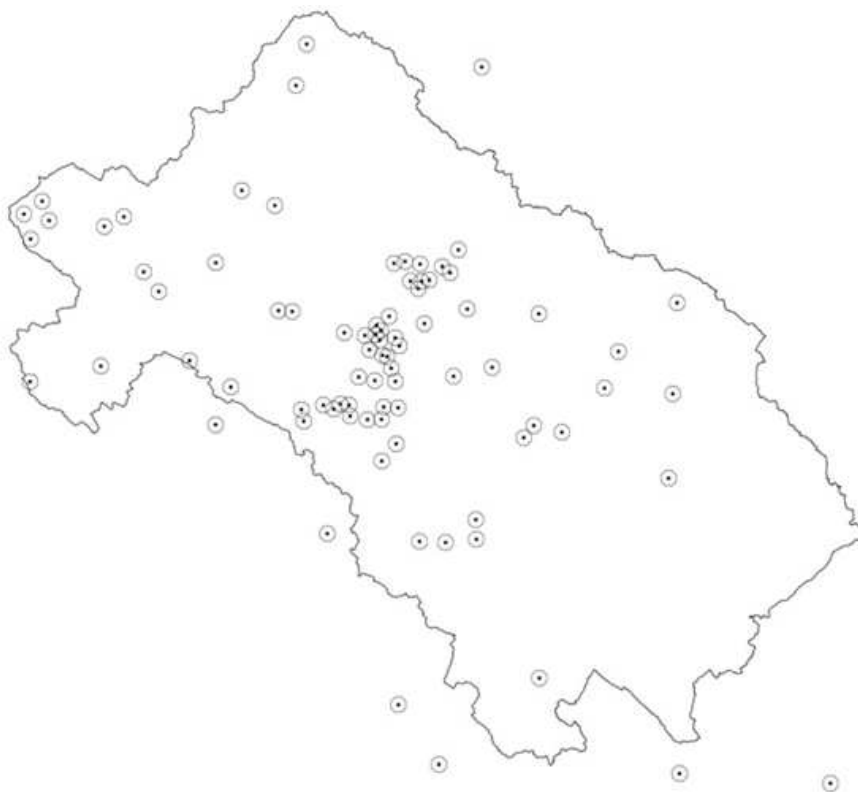

Fig. 7: The distribution of the cities in Zayanderud basin and surrounding areas

686

In the analysis of UHI effect, determination of rural stations as reference stations is a key issue. Choosing the rural stations which are less affected by urbanization led to use a limited number of rural stations in the interpolations. This may overestimate or underestimate UHI effect in some part of the basin. The 21 reference stations as used in this study was the best ones we were able to obtain at present. Development of the stations in the future might lead to more reliable outcomes.

Conclusion

This study aimed to evaluate urbanization effect on mean annual air temperatures in Iran's Zayanderud river basin using analysis of regional trends. The results showed that warming trends dominate over the basin and larger trends are observed in the central basin. Comparison of the pre and post-urbanization trends exhibited the increase of trends caused by urbanization effect. It was estimated that 17% of the overall warming trend in the basin is related to urbanization effect. The strongest effect of urbanization was seen in the centre of the basin where urbanized and the densely populated area is and the weakest urbanization was observed in the eastern and southeastern basin where the cities are less urbanized and the rural societies are dominated. The results presented in this study suggest that urbanization affect the overall warming in Zayanderud basin and may influence imbalance between water consumptions and resources. Further studies are needed to analysis the contribution of urbanization on water shortage in the basin.

In this study, we provide document for a considerable urbanization relic on climate depended on analysis of effects of land-use changes on surface temperature, where quick urbanization has happened. The importance of urban warming relics on zonal average temperature trends is evaluated applying monthly mean temperature series of the station group datasets, which tolerate in homogeneity modification. The spatial template and dignity of our survey are stable with those of urbanization determined by alterations in the percentage of urban population and in satellite-measured greenness. We analysis the surface air temperature record of the past 150 years, examining the concord of the primary data and the standard errors of approximation of the average hemispheric and global evaluates. The twentieth-century warming has been attended by a decline in those regions of the global influenced by exceptionally cool temperatures and to a lesser extent by enhances in areas influenced by exceptionally warm temperatures. A new collection of monthly average surface air temperature for the Northern Hemisphere for 1851-1984 is offered depend on land-based meteorological station data and fixed-position weather ship data. This new land-based hemispheric temperature curve is contrasted with last estimates of Northern Hemisphere temperatures depended on maritime data. In the universal lands, the bias of urbanization influences still exits in the surface air temperature series of many city weather stations to a certain extent. Credible reference climate stations require to be chosen for the finding and correction of the local manmade warming intolerance.

Conclusion

The main conclusions of the experimental work should be presented. The contribution of the work to the scientific community and its economic implications should be emphasized.

Acknowledgement

Use same font size for the content of acknowledgements section.

Funding Information

The authors should acknowledge the funders of this manuscript and provide all necessary funding information.

Author's Contributions

All authors contributed to design the study, write and revise the manuscript.

Ethics

The present Study and ethical aspect was approved by Isfahan University of Technology. The present study was approved by Isfahan University of Technology.

References

Abbasnia, M., T. Tavousi, M. Khosravi and H. Toros, 2016. Investigation of interactive effects between temperature trend and urban climate during the last decades: A case study of Isfahan-Iran. Eur. J. Sci. Technol., 4: 74-81.

Ahmadi, A., A. Khoramian and H.R. Safavi, 2015. Assessment of climate change impacts on snow-runoff processes a case study: Zayanderoud River Basin (In Persian). Iran-Water Resources Res., 11: 70-82.

Almazroui, M., M. Nazrul Islam and P.D. Jones, 2013. Urbanization effects on the air temperature rise in Saudi Arabia. Climatic Change, 120: 109-122. DOI: 10.1007/s10584-013-0796-2

Ataei, H., S. Hasheminasab and S. Cheraghi, 2013. Trend Analysis of the average Monthly Temperature in Isfahan Province. Bull. Environ., Pharmacol. Life Sci., 3: 98-102.

Bayazit, Y., R. Bakiş and C. Koç, 2016. Mapping distribution of precipitation, temperature and evaporation in seydisuyu basin with the help of distance related estimation methods. J. Geographic Inform. Syst., 8: 224-237.
DOI: 10.4236/jgis.2016.82020

Chrysanthou, A., G. van der Schrier, E.J.M. van den Besselaar, A.M.G. Klein Tank and T. Brandsma, 2014. The effects of urbanization on the rise of the European temperature since 1960. Geophys. Res. Lett., 41: 7716-7722. DOI: 10.1002/2014GL061154

Collier, C.G., 2006. The impact of urban areas on weather. Quarterly J. Royal Meteorol. Society, 132: 1-25. DOI: 10.1256/qj.05.199

Ebrahim, M., V. Karthik and B.P. Geetha, 2016. Study of impact of urbanization on the climate change in Dubai and in reducing this effect. Int. Proc. Chem. Biol. Environ. Eng., 92: 53-57.
DOI: 10.7763/IPCBEE

Gandomkar, A., 2011. Investigating the precipitation and temperature change procedure in Zayanderood waters. Int. J. Environ. Chem. Ecol. Geol. Geophys. Eng., 5: 494-499.

Ghahraman, B., 2006. Time trend in the mean annual temperature of Iran. Turk. J. Agric. For., 30: 439-448.

Ghasemi, A.R., 2015. Changes and trends in maximum, minimum and mean temperature series in Iran. Atmos. Sci. Let., 16: 366-372.
DOI: 10.1002/asl2.569

Githui, F.W., 2009. Assessing the impacts of environmental change on the hydrology of the Nzoia catchment, in the Lake Victoria Basin. PhD Thesis, Vrije University Brussels.

Gocic, M. and S. Trajkovic, 2013. Analysis of changes in meteorological variables using Mann-Kendall and Sen's slope estimator statistical tests in Serbia. Global Planetary Change, 100: 172-182.
DOI: 10.1016/j.gloplacha.2012.10.014

Gohari, A., S. Eslamian, J. Abedi-Koupai, A. Massah Bavani and D. Wang *et al.*, 2013. Climate change impacts on crop production in Iran's Zayandeh-Rud River Basin. Sci. Total Environ., 442: 405-419. DOI: 10.1016/j.scitotenv.2012.10.029

Habete, D. and C. Ferreira, 2016. Impact of forecasted land use change on design peak discharge at watershed and catchment scales: Simple equation to predict changes. J. Hydrol. Eng.

Hamdi, R., A. Deckmyn, P. Termonia, G.R. Demare and P. Baguis, 2009. Effects of historical urbanization in the brussels capital region on surface air temperature time series: A model study. J. Applied Meteorol. Climatol., 48: 2181-2196.
DOI: 10.1175/2009JAMC2140.1

Islam, A.W., 2015. Rainy/non-rainy day pattern analysis for North Carolina. Am. J. Climate Change, 4: 1-8. DOI: 10.4236/ajcc.2015.41001

Jones, P.D., D.H. Lister and Q. Li, 2008. Urbanization effects in large-scale temperature records, with an emphasis on China. J. Geophys. Res.
DOI: 10.1029/2008JD009916

Karl, T.R., H.F. Diaz and G. Kukla, 1988. Urbanization: Its detection and effect in the United States climate record. J. Climate, 1: 1099-1123. DOI: 10.1175/1520-0442(1988)001<1099:UIDAEI>2.0.CO;2

Kohler, M.A., 1949. Double-mass analysis for testing the consistency of records and for making adjustments. Bull. Am. Meteor. Soc., 30: 188-189.

Peterson, T.C., K.P. Gallo, J. Lawrimore, A. Huang and D.A. McKittrick, 1999. Global rural temperature trends. Geophys. Res. Lett., 26: 329-332.
DOI: 10.1029/1998GL900322

Pingale, S.M., D. Khare, M.K. Jat and J. Adamowski, 2014. Spatial and temporal trends of mean and extreme rainfall and temperature for the 33 urban centers of the arid and semi-arid state of Rajasthan, India. Atmos. Res., 138: 73-90.
DOI: 10.1016/j.atmosres.2013.10.024

Ren, G. and Y. Zhou, 2014. Urbanization effect on trends of extreme temperature indices of national stations over mainland China, 1961-2008. J. Clim., 27: 2340-2360. 10.1175/JCLI-D-13-00393.1

Ren, G., Y. Zhou, Z. Chu, J. Zhou and A. Zhang *et al.*, 2008. Urbanization effects on observed surface air temperature trends in North China. J. Climate, 21: 1333-1348. DOI: 10.1175/2007JCLI1348.1

Saadatabadi, A.R. and A.A. Bidokhti, 2011. Urbanization effect on local climate in Tehran megapolis. Res. J. Environ. Sci., 5: 1-20.
DOI: 10.3923/rjes.2011.1.21

Sailor, D.J. and L. Lu, 2004. A top–down methodology for developing diurnal and seasonal anthropogenic heating profiles for urban areas. Atmos. Environ., 38: 2737-2748.
DOI: 10.1016/j.atmosenv.2004.01.034

Sen, P.K., 1968. Estimates of regression coefficient based on Kendall's tau. J. Am. Stat. Assoc., 63: 1379-1389.
DOI: 10.1080/01621459.1968.10480934

Tabari, H. and P. Hosseinzadeh-Talaee, 2011. Analysis trends in temperature data in arid and semi-arid regions of Iran. Global Planetary Change, 79: 1-10. DOI: 10.1016/j.gloplacha.2011.07.008

Yan, Z., Z. Li and Q. Li, 2010. Effects of site change and urbanisation in the Beijing temperature series 1977e2006. Int. J. Climatol., 30: 1226-1234.
DOI: 10.1002/joc.1971

Yan, Z.W., J. Wang, J.J. Xia and J.M. Feng, 2016. Review of recent studies of the climatic effects of urbanization in China. Adv. Climate Change Res., 7: 154-168. DOI: 10.1016/j.accre.2016.09.003

Zareian, M.J., S. Eslamian, H.R. Safavi and A. Eslamian, 2015. Effect of climate change on reference evapotranspiration based on weighting methods. Proceedings of the 4th Climate Change Technology Conference, (CTC' 15), Canada, Montreal.