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Full Length Research Paper

Clustering the Iran climate based on climatic elements affecting potential evapotranspiration

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The main purpose of this study is to cluster the Iran climate based on the components of the climate affecting evapotranspiration. For this study, eight components of the climate, the mean temperature difference, the average minimum and maximum relative humidity, number of sunshine hours, monthly amounts of precipitation, days with precipitation higher than 5 and 10 mm, effective precipitation, frequency of occurrence of values over 5 knots per second are used for a 26-year period from 1980 to 2005 and for 64 synoptic and climatological stations of the country. In the clustering process, the best clustering for Iran has been six clusters into which weather stations are distributed appropriately.

Key words: Iran, calibration, data, observations, potential evapotranspiration.

INTRODUCTION

Iran is an arid land with very little rain such that the annual rainfall is less than one third of the world's average precipitation levels. One important way to adapt to this situation especially in agriculture is sustainable and optimum use of water resources (Shakur et al., 2010). So, attempts should be made to use in the best possible way precipitation, surface waters and underground resources. This would not be accomplished unless we understand and plan our needs to water in agriculture. Data on evapotranspiration, which is related to plant life, is crucial in irrigation and drainage planning (Mirzaei et al., 1387; Elsa et al., 2006; DeGaetano et al., 2011; Mukhlisin et al., 2011; Kaya et al., 2011).

This study aims at clustering the Iran climate based on the evapotranspiration components to understand better the behavior of these components in different regions of Iran. This study is a small step in adoption of experimental methods of evapotranspiration in different spheres of climate in Iran.

METHODOLOGY

In the present study, using the components of climate for 12 months of the year, namely, the mean temperature difference, the average minimum and maximum relative humidity, number of sunshine hours, monthly amounts of precipitation, days with precipitation higher than 5 and 10 mm, effective precipitation, frequency of occurrence of values over 5 knots per second are used for a 26-year period from 1980 to 2005 and for 64 synoptic and climatological stations of the country. The purpose of selecting these components is to cluster the weather stations on the basis of components affecting the evapotranspiration. After this stage, it is possible to assign a leveling coefficient to each of the stations based on the similarity between stations in the process of evapotranspiration.

FINDINGS

Clustering of Iran climate based on data on evapotranspiration

To do the clustering based on the evapotranspiration components, stations were selected in a way that cover different climates all around the country. As noted earlier in the methodology, values for each component for 12 months of the year were assigned to a 64 × 96 matrix. 64 denote the number of stations and 96 denotes the number of variables in 12 months of the year. It should be noted that clustering of the country's climate based on the evapotranspiration is as follows:

1. Making a matrix of raw data.

2. Calculation of matrix of raw data.
3. Grouping and calculation of Euclidean distance between each parameter and the average of the group.
4. Integration of the groups using the minimum variance (Ward method) and setting the final grouping.
5. Finally, drawing the dendrogram depicting the integration of groups at several stages.
6. Determining the location of cluster break and final groups achieved (Sadeghi, 2002; de Gaytano and Scholman, 1990; Fole, 1993; Johnson, 1998; Growniwood, 1984).

First, based on the earlier discussions, after doing all steps, clustering of the country's climate was accomplished in 4 groupings of 3, 4, 5 and 6 clusters; the results have been shown in Table 1.

As shown in Table 1, the clustering type 3, about 51 stations among 64 stations under study were in cluster 1 and 8 stations in clusters 2, and finally 5 remaining stations will be assigned in the cluster 3. Although, clustering based on type 3, stations located in clusters 2 and 3 enjoy an acceptable homogeneity in climate, stations located in cluster 1 suffers from inconsistency in climate and especially in evapotranspiration. So, clustering type 3 has not yielded a satisfactory output. But when stations are clustered based on type 4 clustering, station located in Ramsar transfers from cluster 4 to cluster 5. Other than this change, the cluster 1 has 48 stations; cluster 2 has only 3 stations. In this new clustering method, cluster 3 is limited to 8 stations, cluster 4 to 4 stations and cluster 5 is limited to 1 station. The main disadvantage of this clustering is related to cluster 1. As seen in Table 1, a number of these stations such as Jolfa, Mahabad, Maku, Mashhad, etc., are taken same as stations in Semnan, Tabas, Yazd, etc., in terms of evapotranspiration. While in the present method, country has been assigned to 6 clusters, also, station located in Ramsar has been transferred from cluster 5 to cluster 6 and Yashuj, Ilam and Abali, similar to clustering type 5, are assigned to cluster 2. In this clustering method, as seen in Table 1, stations are assigned appropriately to clusters with cluster 3 covering the stations located in the southern coastal regions. If clusters 5 and 6 are integrated based on similar climates, the resulting cluster will cover stations located in the northern coastal regions. In this clustering, the problem of cluster 1 has been resolved and majority of stations with arid and semi-arid weather and distribution in central and southeastern regions are assigned to cluster 1. Cluster 4 covers appropriately stations located in clod regions of northeast and northwest of the country. The majority of those regions, due to their cold climate, are introduced as cold cores of the country in cold season. So, evaluating the earlier discussion, the best clustering for the country is clustering type 6. Based on this clustering the nomenclature of each cluster based on their climates are possible.

Cluster 1or semi-arid to arid regions of central and south east, including stations such as Abadan, Abadeh, Bam, Birjand, Isfahan, Fesa, Ferdows, Garmsar, Qom, Kashan, Kerman, Khash, Nehbandan, Saravan, Semnan, East of Isfahan, Shiraz, Tabas, Sirjan, Yazd, Zabol and Zahedan. The minimum evapotranspiration of 51 mm in this cluster is related to the January and the highest values of 322 mm belong to July. In this cluster, the average annual evapotranspiration is 2119 mm (Figure 1).

Cluster 2 or wet areas and mountainous (highland) north and west stations include Ilam, Abali and Yasouj. In this cluster, minimum of 21 mm evapotranspiration rate was calculated in January with maximum rate of the 272 mm occurring in July. The average annual evapotranspiration in this cluster is 1584 mm (Figure 1).

Cluster 3 or hot areas of the southern coastal regions that includes the Bushehr, Minab, Bandar Abbas, Jask, Bandar Lengeh, Abu Musa Island, Kish and Chabahar. As in previous clusters, the minimum evapotranspiration occurred in January, being 118 mm and the maximum for this component occurs in June, as 265 mm. The average annual evapotranspiration of 2291 mm in the cluster is ranked first among the other clusters.

Cluster 4 or areas from cold and dry regions of northeast to cold and wet regions of northwest, including stations such as Ahar, Bijar, Bojnourd, Dezful, Doshan Tapeh, Qazvin, Quchan, Hamedan, Jolfa, Karaj, Kermanshah, Khorram Abad, Khoy, Mahabad, Maku Mashhad, Urmia, Saqqez, Sabzevar, Sanandaj, Sarakhs, Shahrud, Shahrekord, Tehran, Tabriz and Torbate Heydariyeh. In this cluster, the minimum evapotranspiration of 14 mm occurred in January. The minimum occurred in January and belongs to this cluster for evapotranspiration. The maximum rate of evapotranspiration of 283 mm occurred in July, but in sum, annual evapotranspiration is 1596 mm which assigns it to third place after the third and first cluster.

A combination of clusters 5 and 6 or humid to very humid areas of the northern coastal regions, include areas such as Qaemshahr, Gorgan, Rasht, Ramsar and Noshahr. As with other clusters, in this cluster, the minimum and maximum evapotranspiration have occurred, respectively, 28 mm in January and 161 mm in July. In this cluster, the minimum annual rate of evapotranspiration as compared to other clusters has been 1012 mm.

Conclusion

Iran is an arid land with very little rain, so that the rainfall is less than one-third of the world average rainfall. The correct understanding of the hydrological studies and water requirements, primarily depends on the correct approximation of the level of evapotranspiration. In the

Table 1. Comparison of different clusters (3, 4, 5 and 6) for Iran based on evaporation and transpiration process.

	Station	6 clusters		Station	5 clusters		Station	4 clusters		Station	3 clusters
1	Abadan	1	1	Abadan	1	1	Abadan	1	1	Abadan	1
2	Abadeh	1	2	Abadeh	1	2	Abadeh	1	2	Abadeh	1
3	Abali	2	3	Abali	2	3	Abali	1	3	Abali	1
4	Jazireh	3	4	Jazireh	3	4	Jazireh	2	4	Jazireh	2
5	Ahar	4	5	Ahar	1	5	Ahar	1	5	Ahar	1
6	Bam	1	6	Bam	1	6	Bam	1	6	Bam	1
7	Bandar a	3	7	Bandar a	3	7	Bandar a	2	7	Bandar a	2
8	Bandar l	3	8	Bandar l	3	8	Bandar l	2	8	Bandar l	2
9	Bijar	4	9	Bijar	1	9	Bijar	1	9	Bijar	1
10	Birjand	1	10	Birjand	1	10	Birjand	1	10	Birjand	1
11	Bojnurd	4	11	Bojnurd	1	11	Bojnurd	1	11	Bojnurd	1
12	Bushehr	3	12	Bushehr	3	12	Bushehr	2	12	Bushehr	2
13	Chahbaha	3	13	Chahbaha	3	13	Chahbaha	2	13	Chahbaha	2
14	Dezful	4	14	Dezful	1	14	Dezful	1	14	Dezful	1
15	Doushan	4	15	Doushan	1	15	Doushan	1	15	Doushan	1
16	Esfahan	1	16	Esfahan	1	16	Esfahan	1	16	Esfahan	1
17	Fassa	1	17	Fassa	1	17	Fassa	1	17	Fassa	1
18	Ferdous	1	18	Ferdous	1	18	Ferdous	1	18	Ferdous	1
19	Garmsar	1	19	Garmsar	1	19	Garmsar	1	19	Garmsar	1
20	Ghaemshr	5	20	Ghaemshr	4	20	Ghaemshr	3	20	Ghaemshr	3
21	Ghazvin	4	21	Ghazvin	1	21	Ghazvin	1	21	Ghazvin	1
22	Ghom	1	22	Ghom	1	22	Ghom	1	22	Ghom	1
23	Ghoochan	4	23	Ghoochan	1	23	Ghoochan	1	23	Ghoochan	1
24	Gorgan	5	24	Gorgan	4	24	Gorgan	3	24	Gorgan	3
25	Hamedan	4	25	Hamedan	1	25	Hamedan	1	25	Hamedan	1
26	Ilam	2	26	Ilam	2	26	Ilam	1	26	Ilam	1
27	Jask	3	27	Jask	3	27	Jask	2	27	Jask	2
28	Jolfa	4	28	Jolfa	1	28	Jolfa	1	28	Jolfa	1
29	Karaj	4	29	Karaj	1	29	Karaj	1	29	Karaj	1
30	Kashan	1	30	Kashan	1	30	Kashan	1	30	Kashan	1
31	Kerman	1	31	Kerman	1	31	Kerman	1	31	Kerman	1
32	Kermansh	4	32	Kermansh	1	32	Kermansh	1	32	Kermansh	1
33	Khash	1	33	Khash	1	33	Khash	1	33	Khash	1
34	Khorrama	4	34	Khorrama	1	34	Khorrama	1	34	Khorrama	1
35	Khoy	4	35	Khoy	1	35	Khoy	1	35	Khoy	1
36	Jazireh	3	36	Jazireh	3	36	Jazireh	2	36	Jazireh	2

Table 1. Cont'd

37	Mahabad	4	37	Mahabad	1	37	Mahabad	1	37	Mahabad	1
38	Makoo	4	38	Makoo	1	38	Makoo	1	38	Makoo	1
39	Mashhad	4	39	Mashhad	1	39	Mashhad	1	39	Mashhad	1
40	Minab	3	40	Minab	3	40	Minab	2	40	Minab	2
41	Nehbanda	1	41	Nehbanda	1	41	Nehbanda	1	41	Nehbanda	1
42	Noushahr	5	42	Noushahr	4	42	Noushahr	3	42	Noushahr	3
43	Oroomieh	4	43	Oroomieh	1	43	Oroomieh	1	43	Oroomieh	1
44	Ramsar	6	44	Ramsar	5	44	Ramsar	4	44	Ramsar	3
45	Rasht	5	45	Rasht	4	45	Rasht	3	45	Rasht	3
46	Sabzevar	4	46	Sabzevar	1	46	Sabzevar	1	46	Sabzevar	1
47	Saghez	4	47	Saghez	1	47	Saghez	1	47	Saghez	1
48	Sananda	4	48	Sananda	1	48	Sananda	1	48	Sananda	1
49	Sarakhs	4	49	Sarakhs	1	49	Sarakhs	1	49	Sarakhs	1
50	Saravan	1	50	Saravan	1	50	Saravan	1	50	Saravan	1
51	Semnan	1	51	Semnan	1	51	Semnan	1	51	Semnan	1
52	Shahre k	4	52	Shahre k	1	52	Shahre k	1	52	Shahre k	1
53	Shahroud	4	53	Shahroud	1	53	Shahroud	1	53	Shahroud	1
54	Shargh e	1	54	Shargh e	1	54	Shargh e	1	54	Shargh e	1
55	Shiraz	1	55	Shiraz	1	55	Shiraz	1	55	Shiraz	1
56	Sirjan	1	56	Sirjan	1	56	Sirjan	1	56	Sirjan	1
57	Tabass	1	57	Tabass	1	57	Tabass	1	57	Tabass	1
58	Tabriz	4	58	Tabriz	1	58	Tabriz	1	58	Tabriz	1
59	Tehran m	4	59	Tehran m	1	59	Tehran m	1	59	Tehran m	1
60	Torbate	4	60	Torbate	1	60	Torbate	1	60	Torbate	1
61	Yasouj	2	61	Yasouj	2	61	Yasouj	1	61	Yasouj	1
62	Yazd	1	62	Yazd	1	62	Yazd	1	62	Yazd	1
63	Zabol	1	63	Zabol	1	63	Zabol	1	63	Zabol	1
64	Zahedan	1	64	Zahedan	1	64	Zahedan	1	64	Zahedan	1

present study, the first step was to devise the appropriate equation of evapotranspiration in the country. Based on the effective components of evapotranspiration, 64 synoptic and climatological stations were used. The evaluation indicated that classification of the country based on clustering type 6 provides appropriate conditions for clustering. In this clustering, the maximum evapotranspiration belonged to cluster 3 or hot climate of coastal regions of the south. It is obvious that the maximum and minimum is attributable to low latitude of the location of stations and perpendicular reception of solar energy by the soil. Unlike this cluster, clusters 5 and 6 enjoy the minimum level of evapotranspiration. This cluster covers humid to very humid regions of the northern coasts. Due to low altitudes of the stations, per se contributing to the atmospheric pressure and lowering the solar radiations and also higher latitudes helps decrease the rate of potential of evapotranspiration as compared to other clusters.

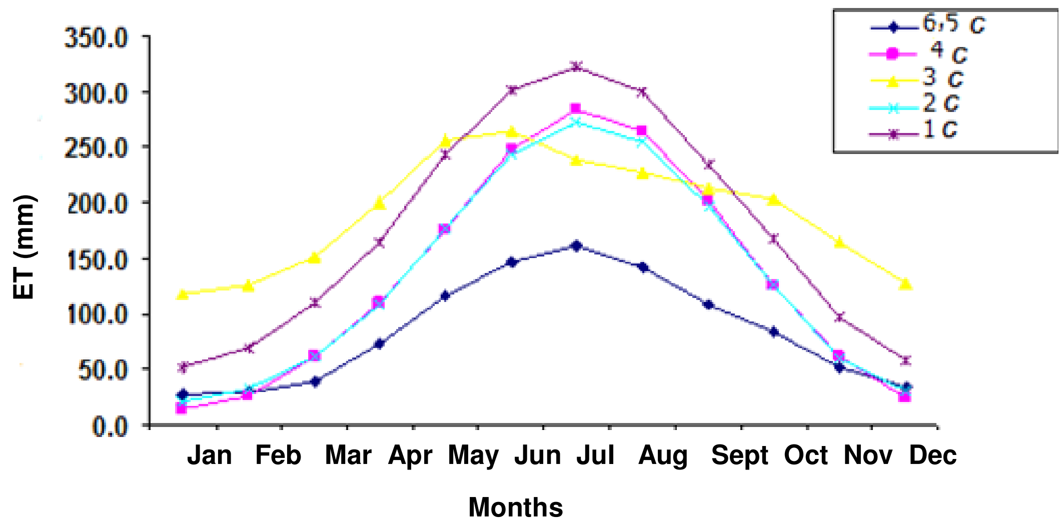

Figure 1. Long-term average (2005 to 1980) monthly evapotranspiration for different clusters of study.

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