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Investigation of Iran Vulnerability Trend to Desertification with approach of climate change

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Abstract-- **In this paper for study of amount of Vulnerability of Iran to Desertification is used of bioclimatic index of UNEP (United Nation Environment Programme). First Annual temperature average and total of annual precipitation from 45 synoptic meteorological stations for a 30 years period (1976-2005) has been collected the Meteorological Organization of Iran. Then UNEP index are computed for all of studied stations. In final using Mann-Kendall graphical –statistical test was investigated UNEP changes trend in Iran.**

On the basis of UNEP index is observed that most of areas of Iran have arid and semi-arid climates. With respect to desertification intensity class, these two kinds of climates have classes of severe and very severe. After those two kinds of climates, ultra arid, dry sub-humid, very humid and sub-humid climates have the most area in Iran, respectively.

Results of Mann-Kendall test show that in three stations of Birjand, Tabriz and Mashhad, UNEP index changes trend have sign of tendency from semi-arid climate to arid climate. Changes trend at two stations of Oroomieh and Khoy have tendency from dry sub-humid climate to semi-arid climate. Changes trend at station of Sanandaj have sign of replacement between semi-humid climate with semi-arid climate and station of Yazd have tendency to ultra-arid from arid climate.

But station of Zabol at north of Sistan and Baluchistan province, have been alone station that has had positive trend, that is its changes trend have been from ultra-arid climate to arid climate. Changes trend of all of these stations at level of $\alpha = 0.05$ are significant.

Keywords- Desertification; UNEP index; Mann-Kendall test; Trend; Iran

I. INTRODUCTION

The researches done in many different areas in Iran and the world show that the phenomenon of desertification and its result affects on the processes such as drought [3, 2, 16], desert area expanding [6], pasture ruination [15, 8, 11], soil brining [14], underwater surface loss and their quality reduction[10], surface water reduction [13, 19], dairies fatality, poorness and poverty of thousands of people due to the impermanent ecosystems (specially in arid and semiarid areas) and avaricious human.

Climate change was noticed as an affective feature on severity and expanding the desertification process by many different scientists from different views. Of its main subjects are changes in rate of earth surface Albedo due to surface covering feature changes [12], the effect of increasing mine dust on cloud rain capability rate reduction role [20, 7, 18], the effect of sea level temperature pattern on atmospheric process [4, 5, 18, 1, 17] and relation between desertification and drought [16].

As we know Iran is located in the desert zone of the north hemisphere and its major part is surrounded with subtropical high pressure, so the most parts form arid and semiarid areas that have rainfall between 50-250 mm. Desert and desertification is a phenomenon that threatens our environment and economical life. Therefore, regarding the increasing heat in the world and successive droughts in the country, this question is raised that Does this global heating have affects on Iran vulnerability in desertification or not ? So, this survey aims to study the climate change process UNEP index in Iran area using Mann-Kendall graphical statistical test that is a suggestive method in the world Meteorological Organization for analyzing time series.

II. MATERIALS AND METHODS

To study Iran climate change trend and its effects on severity and expanding desertification process , the data for two parameters about annual temperature average and monthly total rainfall of synoptic meteorological stations for a 30 year period (1976-2005) were obtained from Iran Meteorological Organization. We can see the distribution of studied stations in Iran in Figure1.

To study Iran vulnerability to desertification, we used United Nation Environment Programme (UNEP) index. UNEP index is calculated as following:

$$R = \frac{P}{ETP} \tag{1}$$

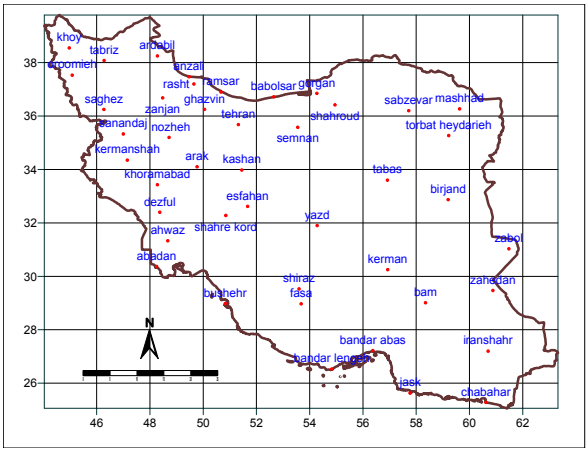

Figure 1. location map and studied station distribution

Where R is UNEP numerical index, P is the annual rainfall average in mm, ETP is potential evapotranspiration in mm. It is necessary to say that calculation of potential evapotranspiration in this relation is done using Thornthwaite Index. At last, we classify the arid, semiarid… areas based on this index (table 1).

TABLE 1: ARID REGIONS CLASSIFICATION BASED ON UNEP ARID INDEX

Desertification alarm class	UNEP arid index	Climatic Regions
Real desert	R<0.05	Ultra arid
Very high	0.05<R<0.2	Arid
High	0.2<R<0.5	Semi-arid
Mid	0. 5<R<0.65	Dry sub-humid
Low	0.65<R<0.75	Sub-humid
Lack of desertification danger	0.75<R	Humid and very humid

Then Providing UNEP index time series for 45 studied stations through the country, we used Mann-Kendall graphical statistical test in the second stage to study this index change trends. Kendall statistic (t) to test the null hypothesis, lack of trend in time series was calculated based on the following formula:

$$t = \frac{4\sum H}{N(N-1)} - 1 \qquad (2)$$

Where, $\sum H$ IS THE CUMULATIVE FREQUENCY OF SOME RANKS THAT ARE HIGHER EACH ROW AND N IS THE YEARS OF A STATISTICAL period THAT IS 30 YEARS HERE. KENDALL STANDARD STATISTICS (t_0) WAS CALCULATED AS THE FOLLOWING:

$$t_0 = \pm tg\sqrt{\frac{4N+10}{9N(N-1)}} \qquad (3)$$

IN THIS FORMULA, tg IS THE CONFIDENCE DEGREE OR SIGNIFICANT LEVEL THAT AMOUNTS TO 1.96 BASED ON THE PROBABILITY LEVEL OF 95%? SO, IF THIS IS 1.96, t_0 WILL EQUAL TO ± 0.21 . NOW, WE HAVE THREE FOLLOWING STATES REGARDING THE OBTAINED CRITICAL AMOUNT:

- If +0.21>t>-0.21, we don't have any time series trend.
- If t<-0.21, we have a negative trend in time series.
- If t>+0.21, we have positive trend in time series.

In the second step, if we have a significant trend, we will determine time and kind changes using Mann-Kendall graphical statistics. To do this, U and U' will be calculated. We will obtain these two components based on the following formulas.

$$E(t_i) = \frac{n_i(n_i-1)}{4} \qquad (4)$$

$$V(t_i) = \frac{n_i(n_i-1)(2n_i+5)}{18} \qquad (5)$$

$$U(t_i) = \frac{\sum t_i - E(t_i)}{\sqrt{V(t_i)}} \qquad (6)$$

In this formula, n_i is the number of row. U' is inverse U. Mathematical expectation, Variance and U' component will be calculated as 7-9:

$$E'(t_i') = \frac{(N-n_i+1)(N-n_i)}{4} \qquad (7)$$

$$V'(t_i') = \frac{(N-n_i+1)(N-n_i)(2(N-n_i+1)+5)}{75} \qquad (8)$$

$$U'(t_i') = \frac{\sum t_i' - E'}{\sqrt{V'}} \qquad (9)$$

Calculating above amounts, U and U' will be drawn graphically. Finally, zoning of desertification trend is drawn in Surfer software using Kriging Method.

III. RESULTS

We can see that most of Iran is in center, east, south, North West and north east dominates with arid and semiarid areas. Caspian Sea strip has humid and very humid climate, Alborz northern heights have semi humid climate and its south heights and some parts of the west dry sub humid

climate. The ultra arid climate is seen in central Iran, Sistan plain and south of Sistan and Balouchestan province (Fig. 2).

Calculating the Mann-Kendall statistic for the whole studied stations shows a descending trend in most of UNEP time series. But only 7 stations have had significant descending trend such as Sanandaj, Yazd, Tabriz, Oroomieh, Khoy, Birjand and Mashad and Zabol station was the only one that has had a significant positive increasing trend. So that in Birjand, Tabriz and Mashhad stations that have semi arid climate and located in high level of desertification hazard, UNEP index changing trend shows the climate from semi arid toward arid climate that its desertification hazard changes into so high. (figure3). Oroomieh and Khoy in North West of Iran have a trend toward semi-arid that in desertification hazard level, they are tended from average to so high one. The trend of Sanandaj Station in west of Iran shows replacing sub-humid and semiarid climates and Yazd station from arid into ultra arid climate. Of course their desertification hazard level will be changed accordingly. (Fig. 3)

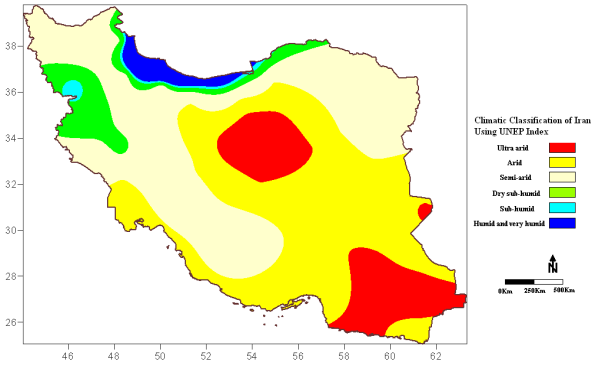

Figure 2. – Iran climate fielding using UNEP index

But, Zabol, in the north of Sistan and Balouchestan in east of Iran, was the only station that has had positive UNEP trend, from ultra arid towards arid climate. So, this station shows the desertification hazard level from real desert into so high level one. (Fig. 3)

We can see the spatial distribution of significant changes in time series of station's UNEP index in fig. 4. In this, it is clear that in west and North West and also north east are the areas that their climate changes will lead to their desertification trend strengthening. Although the statistical period is so short to comment about confirming climate changes, but we can know that as a marker of starting changes.

IV. DISCUSSION

Iran is located in the big desert belt of Atlantic Ocean to China, has desertification phenomenon due to brittle and sensitive specifications of its dominate climate and human unconscious contacts with environment. We can see that most of Iran is dominated with arid and semiarid climate and is in high and so high level of desertification hazard. Then, we have ultra arid, semi moist arid, high moist and semi moist climates in Iran.

The results of Mann-Kendall statistics for three stations of Birjand, Tabriz and Mashhad, which have semiarid climates and are in high level of desertification hazard, UNEP index change trend shows it from semiarid into arid climate, so their hazard level changes into the so high level. Two stations of Oroomieh and Khoy in North West of Iran with semi moist arid climate, have tends toward semiarid climate and so high level from the average one. The changes in Sanandaj in the west show the displacing semi moist with semiarid and Yazd from arid toward ultra arid one. So, their desertification hazard level will change accordingly.

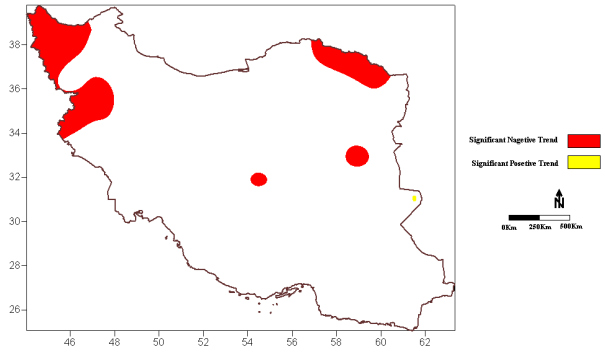

Figure 4 - Fielding trend of UNEP arid index changes throughout Iran

But, Zabol is the only one with positive UNEP trend from ultra arid toward arid climate. So, its desertification level is from real desert into so high one. These changes in UNEP index, that can be the results of changes in the other climate elements such as minimum temperature, maximum temperature and rainfall amount, were studied before by Tavoosi et al [19]. Their results confirm these changes especially in the west and North West. If these climatic situations follow with other strengthening desertification elements such as destroying jungles, underwater source decrease, water erosion… can be effective in destroying this land. So, each change in the climate will be noticed as the first influential chain in other desertification processes.

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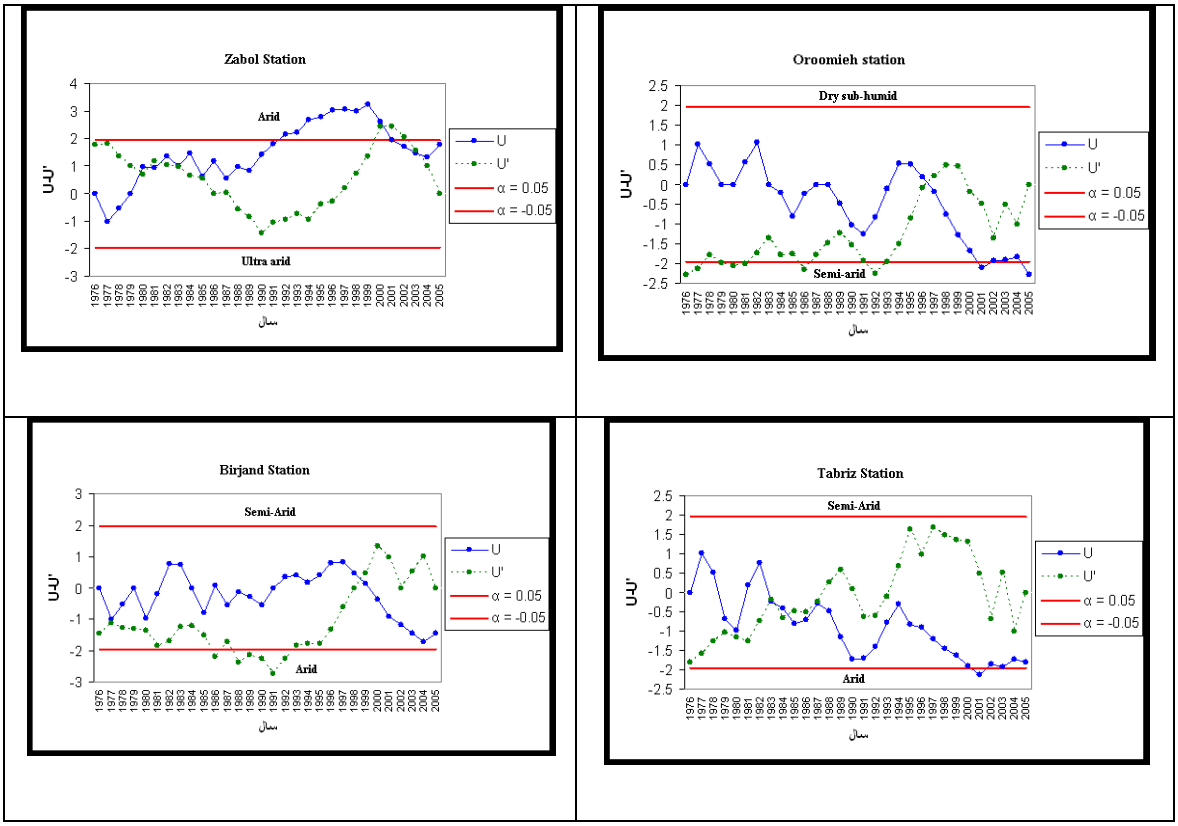

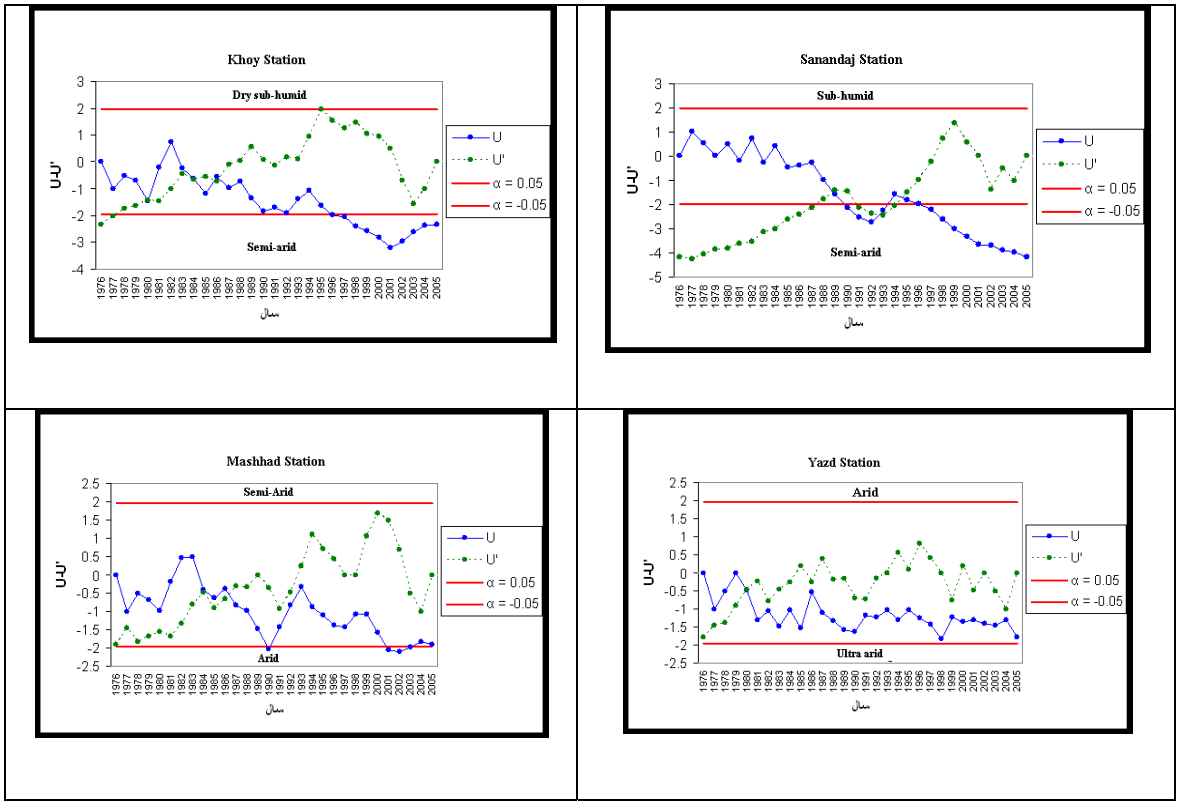

Figure 3. U and U' change diagrams, the UNEP arid index of stations with meaningful trend