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Droughts as an Appearance Form of Climate Changes

Mamedov AS*, Mamedova VR and Calalova VY

Baku State University, Azerbaijan

***Corresponding author:** Asger Mammadov, Baku State University, Baku, Azerbaijan Republic, Azerbaijan, Email: Asger_mammadov@mail.ru

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Abstract

Drought, as one of the consequences of contemporary warming, has become one of the main topics discussed by researchers at the moment. Thus, with an increase in the temperature, there observes the decrease in the precipitation, an increase in the frequency of the drought in some regions of the world. Naturally, in this case, the threat of the decrease in crop yields and agricultural productivity is inevitable. Of course, in some regions, the revers processes can occur, in which an increase in the temperature can lead to the increase in the precipitation, the decrease in the tendency of the drought, and in this case productivity can increase. On the other hand, methods are presented to determine the probable risks of each of processes that will affect the dynamics of the productivity during the warming period. For this purpose, it is proposed to use the trend angle coefficient.

Keywords: Trend; Angle Coefficient; Drought; Productivity

Abbreviations: SPIM: Standardized Precipitation Index Method.

Introduction

In the article, drought-productivity relations on the north-eastern slope of the Lesser Caucasus region of Azerbaijan have been studied according to the index based on precipitation anomalies (SPI) [1]. For this purpose, precipitation data covering 1992-2019 of Ganja, Gazakh, Aghstafa, Shamkir and Gedabey observation posts are used. At the same time, the drought has been determined using the standardized precipitation index method (SPI) for each month of the year [2,3]. This region is one of the economically important (Ganja-Kazakh) economic regions of Azerbaijan. It should be noted that it is more important to assess the drought by months. It would not be correct to consider the solution of the problem acceptable for shorter or longer periods (taking into account the vegetation periods of plants). The problem is mainly to assess the impact of the effects of the warming period on the agricultural productivity. Nowadays, there is some disagreement among researchers as to whether productivity will increase or decrease due to the global warming. Furthermore, also there are currently gaps in the assessment of risks, which are affect to the productivity. The article shows certain methods to solve these problems. First of all, I would like to note that the graphs on months are not given due to the limited volume of the article, only graphs based on the annual data are given. Only analyzes of monthly graphs are presented.

Drought in (the) investigating (exploring) regions

According to the research, conducted in Ganja for the months of 1992-2018, the decrease in the tendency of the drought has been observed in the remaining months of the mentioned period, except for June, September and December. So, the spring vegetation period of the mentioned plants (1992-2018) has been not very dangerous for Ganja region. The effects of the droughts have been small and the intensity has been low. In general, the driest months in Ganja have been observed in spring and summer, and the leastin autumn and winter. The decrease in the tendency of the drought in Ganja is reflected in its annual data figure 1.

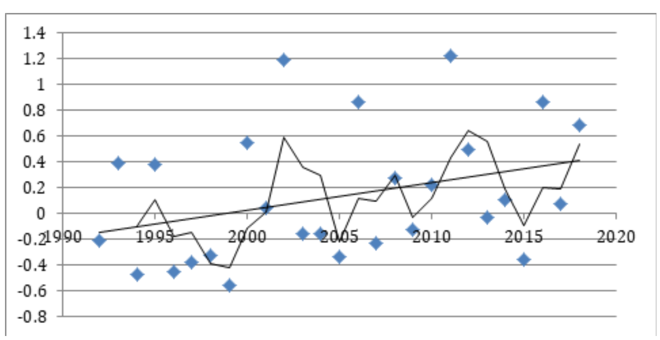

Figure 1: SPI drought indexes on the annual data in Ganja.

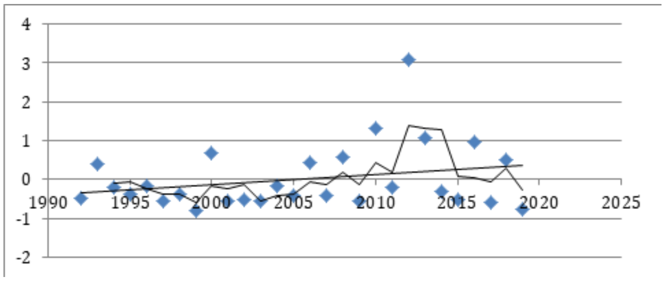

Figure 2: SPI drought indexes on the annual data in Gazakh.

In the Gazakh region of the country, in all months of the year, the drought index has been decreased more weakly than in Ganja. Drought intensity has been higher in summer and autumn, and relatively stable, weak and moderate in other months of the year. In January-June there has been a slight decrease in the value of the trend, and in July-December there has been a slight increase. The decrease in the drought index is reflected in the annual data of the region. In Aghstafa, the largest decrease in SPI values has been observed in January and July. Relatively low-intensity droughts have been observed in June, September, November and December. In the remaining months, the trend curve has been found to change mainly around the norm. In the annual data, there is a decrease in the values of the SPI index in 1992-2019y.y.

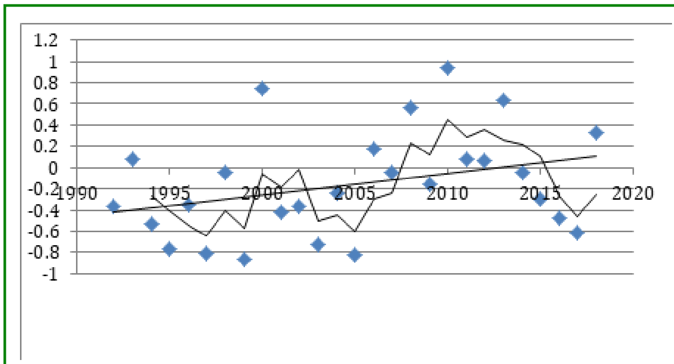

Figure 3: SPI drought indexes on the annual data in Aghstafa.

In Shamkir in January, February, March and May, drought index values have been decreased, in April and May, some stability has been observed, and in June, August, September and December, the increase has been observed.

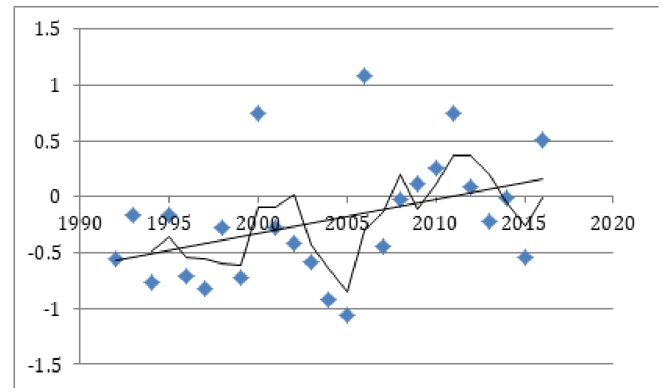

Figure 4: SPI drought indexeson the annual data in Shamkir.

In Gedabey, except for September and December, the values of the drought index have been decreased in the remaining months. Only in December there has been the increase, and in September there has been a certain stability. The annual values of the index have been decreased.

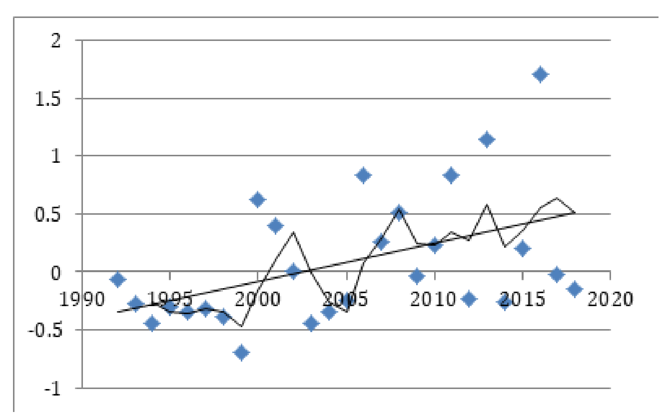

Figure 5: SPI drought indexeson the annual data in Gedabey.

Thus, it has been found that there has been a decrease in the trend of drought in all regions of the studied region in 1992-2019. Therefore, the impact of drought on changes in productivity (especially the yield of grain) should be small. To clarify the issue, let's look at table 1 below the grain yield data.

Productivity pass in (the) regions

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Ganja	13,5	14,3	33,9	25,0	19,0	24,1	22,5	-	-	33,4	13,2	-	21,0	21,9	23,9	22,1	12,5	23,5	21,8	22,7
Gazakh	28,6	27,2	29,0	29,0	29,3	26,0	28,0	29,7	30,8	27,0	25,0	25,9	28,1	26,0	26,7	31,1	33,9	36,0	36,6	37,8
Gedabey	13,9	18,7	20,3	22,4	23,7	29,4	29,9	30,2	31,5	31,8	30,3	31,5	31,1	31,2	28,6	26,5	26,7	27,0	27,2	

Table 1: Wheat yield in the studied regions, cents / ha.

According to table 1, the years with the lowest productivity are 2000, 2001, 2010 and 2016. According to the agro-climatic indicators in Ganja, the weather conditions have beennot favorable for the development of autumn wheat due to the dry (weak and moderate intensity) autumn and winter months of 2000 and 2001 years. At the same time, dry weather (mainly low-intensity drought) in February, March and April hindered the development of spring wheat. The reasons for the decline in productivity in 2010 and 2016 can be explained not by drought, but by relatively high rainfall. In those years, in Ganja region, there have beenshort-term weak droughts in some months, but the amount of the precipitation during the wheat growing season has been about 1 mm above the norm table 1.

Unlike Ganja, Gedabey region of the studied region differs in climatic and agro-climatic indicators of mountainous areas. Thus, the years of the high productivity here are mainly in 2006-2013. In subsequent years of increasing global warming, the productivity fell to 12-13%. The reasons for this can be explained by the drought.The above-normal precipitation, observing in the autumn and spring of these years, has been provided favorable conditions for the development of both autumn and spring wheat. The lowest productivity in the region has been varied between 13.9 and 20.3 cents / ha in 2000-2003, which is about 58% of the norm table 1. This is due to the fact that in autumn, especially in September and October, the occasional rainy weather hinders the sowing of autumn grain, and the droughts in winter and spring hinder the development of spring wheat figure 3.

Valuing of the drought risk

It is known that the increase or decrease in the productivity may not be due to the drought. It is possible to clarify the issue according to the angle of the trend. In this case, if the angle coefficient of the drought trend corresponds to the angle coefficient of the productivity trend, then the decline in the productivity will be due to the drought. Otherwise, there are other factors that affect the productivity. If we denote this angle by k_q for the drought, then the condition $-1<k_q / k_m<1$ is accepted to estimate the productivity. In this case, the productivity is increased with the decrease in the k_q/k_m ratio. Thus, the greater k_q/k_m ratio means the greater impact of the drought on the productivity. However, the higher value of the k_q angle factor, the greater the impact of drought on agricultural productivity [2,3].

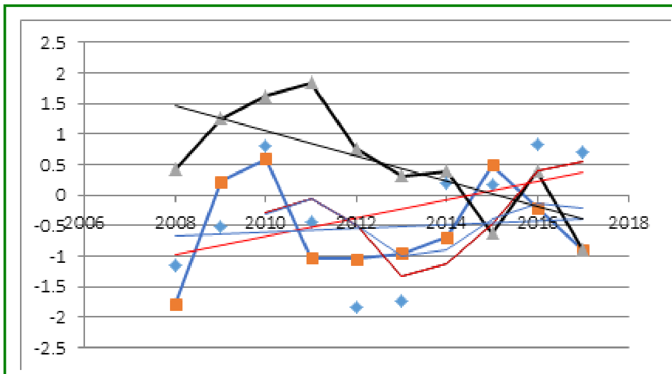

Figure 6: SPI - drought indexes in 2008-2017; red- Ganja; blue - Aghstafa; black - Gedabey.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Ganja	0.17	0.14	0.13	0.02	0.01	0.13	-0.08	0	-0.04	0.15	0	0.04
Aghstafa	0.12	0	0.06	0.05	0.01	-0.001	0.002	0	-0.001	0.001	-0.001	0.002
Gedabey	0.59	0.55	0.24	0.21	0.18	0.08	0	-0.07	0	0.24	0.06	0.19
Shamkir	0.003	0.001	0.002	0	0.002	0.0003	0.001	-0.002	-0.001	0.001	0	-0.0009
Gazakh	0.002	0.003	0.003	0	0.0007	0	0	-0.001	-0.002	0.001	-0.001	-0.001

Table 2: Monthly estimates of drought trend inclination angles (in radians).

Result

Thus, the angular coefficient of the trend for the productivity in Gazakh region is defined as 0.003, and for Gedabey -0.006. As shown in the table 1, figure 2 and figure 6, there is an increase in the trend of productivity in both regions. Thus, global warming in these regions has led to an increase in productivity, not a decrease. In this case, of course, it is necessary to have a certain quantitative indicator. For this, it is necessary to find the angular coefficient of the trend in Gazakh and Gedabey regions (according to the SPI-index). Figure 6 shows the value of the angle coefficient for drought in the Gedabey region - 0.001, and in Gazakh - 0.001.According to the calculation on 0.001 / 0.003 = 0.33, the effect of the drought on the productivity in Gazakh is 33%, and according to the calculation -0.001 / 0.006 = 0.17, this effect is 17% in Gedabey.Thus, the role of any factor in increasing productivity can be determined by estimating the angle coefficients.

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