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A – study design
B – data collection
C – statistical analysis
D – data interpretation
E – manuscript preparation
F – literature search

Investigation of droughts in the Lankaran region of Azerbaijan

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Abstract

As part of the World Food Program, investigating droughts is within the scope of our interest. Therefore, this paper presents results of studies on droughts in one of the most important economic regions of Azerbaijan. There are different methods to investigate drought. As chosen region is characterised by large precipitation, we preferred to use the *SPI* method to carry on our study. During the research, dry years were determined according to the seasonal and annual data from weather stations in the province.

Key words: *drought, SPI, Lankaran, climatic zone, river flow*

INTRODUCTION

According to the UN World Water Report, during the period 1991–2000 the number of people affected by natural disasters increased from 147 million to 211 million. During this period 90% of 2557 natural disasters were caused by water, half of that by floods and 11% by drought.

As a result of natural disasters, 66 500 people were killed during the specified period, 97% of which occurred in developing countries. The material damage caused by disasters increased from 30 billion dollars (1990) to 70 billion dollars (1999). This figure illustrate the increasing risk of floods and droughts. It is known that the problem of water deficit in the earth's arid zones becomes severe and that dry periods happen more often.

Drought exerts more profound effect in poor countries dry farming is carried out. It is assumed that in order to minimize damage caused by droughts it is sufficient to change the form of land use, to build water reservoirs and to use of wells for irrigation. Crop products should be insured and the interests of priority water users should be protected. Replacement of the cultivated crop varieties with others and the construction of water reservoirs can be examples for long-term measures.

Generally, in order to reduce the risk of potential drought this natural phenomenon should be studied and forecasted. Losses should be assessed depending on the severity of drought and complex counteracting measures should undertaken with the calculation of necessary funds. The strategy of more efficient use of water in dry periods has to be worked out. Since agriculture consumes 70% of water all over the world, farmers should prefer drought-resistant crops and water losses in irrigation systems have to be minimized.

The problem of drought is very relevant for Azerbaijan, because the country's territory is situated in arid zone 50% of which has semi-desert and dry steppe climate. According to data from 1984 and 1986 data the republic economy lost approximately 3 million dollars as a result of drought and floods.

Long term droughts in the region seriously affects the level of the Caspian Sea. For example, in 1930–1940s in the plains of Eastern Europe (the Vol-

ga River Basin) the level of the Caspian Sea decreased sharply as a result of drought lasting nearly 10 years. Increasing precipitation in 1978–1995, on the contrary, increased the level of the Caspian Sea. In the last 15 years the level has not change. Generally, the variability of the Caspian Sea level can be considered an indicator of climate changes in the region [MAMMADOV *et al*. 2000].

THE STUDY AREA

6.1 thousand km^2 of the study area (7.2% of the Azerbaijan territory) is a humid subtropical zone. According to Keppen's classification, three types of climate are observed there:

- mild climate with hot, dry summers (CS)
- moderately warm climate with equal distribution of humidity (CF)
- semi-desert and dry steppe climate (BS).

The area receives the highest precipitation in Azerbaijan (more than 1300 mm per year). However, in the Lankaran lowland temperate climate with dry summers prevails in the plain part of the area and crop production is possible only with irrigation (Tab. 1).

Table 1. Hypsometric and climate data of Lankaran region from meteorological stations

Station	Altitude m	Average annual precipitation mm	Average annual temperature °C	Climate type
Goytepe	2	600	14.4	CS
Lankaran	37	1 402	14.0	CS
Astara	–21	1 398	14.2	CS, CF
Kalvaz	1 567	670	8.5	CS
Yardimly	720	645	11.9	BS, CS
Lerik	1 070	640	9.7	CS

Citrus plants, vegetables, and tea are grown in the plain part. Cattle are bred and dry farming is carried out in the mountain part of the Lankaran region (Kalvaz, Yardimly). Precipitation inversion is observed in the studied territory. Annual precipitation increases to 500–700 m a.s.l., then it starts to decrease. Among the operating weather stations in the territory only Lankaran station has been working since the 19th century, the rest of them have been established in the last 15–20 years.

METHODS

Standardized precipitation index (*SPI*) is used to determine arid years in western countries [ŁABĘDZKI 2007; THOMAS, NOLAN 1993]. This index is calculated according to the following formula:

$$SPI = \frac{X_i - \overline{X}}{S_x} \qquad (1)$$

where:

X_i – atmospheric precipitation for each year (annual or monthly);

$\overline{X}$ – long-term average precipitation;

S_x – standard deviation.

According to the *SPI* method the severity of a drought is determined as follows (Tab. 2).

Table 2. Classification of the *SPI* values and drought category

SPI	Drought category
0.0–(–0.99)	near normal
(–1.0)–(–1.49)	moderate drought
(–1.5)–(–1.99)	severe drought
≤ –2.0	extreme drought

Drought in the Lankaran region of Azerbaijan was investigated with the *SPI* method. Taking plant vegetation period as the main factor, calculations were made for spring, autumn, and years.

DROUGHT ASSESSMENT

The springs of 2000, 2001, 2006 and autumns of 2002–2005 were dry. According to table1 and calculations, the drought in spring 2001 and in autumn 2002 was estimated as moderate and severe and for the rest of the years as near normal (Tab. 3, 4).

Table 3. *SPI* values for spring in the Lankaran region

Years	Lankaran	Astara	Yardimly	Goy tepe	Kalvaz
1998	–1.08	–0.90	–1.77	–0.72	1.22
1999	–0.11	0.02	0.86	0.79	–0.68
2000	–0.51	–0.42	–0.06	–0.49	–0.27
2001	–1.59	–1.90	–1.42	–1.28	–1.90
2005	–0.07	0.10	–0.64	–0.86	0.78
2006	–0.84	–0.75	–0.46	–0.73	–1.49

Table 4. *SPI* values for autumn in the Lankaran region

Years	Lankaran	Astara	Yardimly	Goytepe	Kalvaz
1998	0.47	1.05	0.12	–0.36	–0.62
2002	–1.11	–1.23	–1.63	–1.30	–1.35
2003	–0.09	–0.11	–0.28	0.03	–0.83
2004	0.60	0.14	–0.29	–0.44	0.11
2005	–1.57	–1.22	–0.81	–0.23	–0.57
2007	–0.90	–1.74	–1.03	–0.77	2.44

As observations have been made since 1891 in the Lankaran station, calculations cover a long period. Data from 106 years of drought for spring and autumn are given on Figures 1 and 2.

Due to the climate variability observed in the XX century, 22 droughts were noted in 1891–1940, 21 in the years 1940–1975 and 22 were registered in the last warming period in the years 1976–2007 (Fig. 1). Drought that occurred in the first and the third period constituted 34% of all spring droughts, droughts

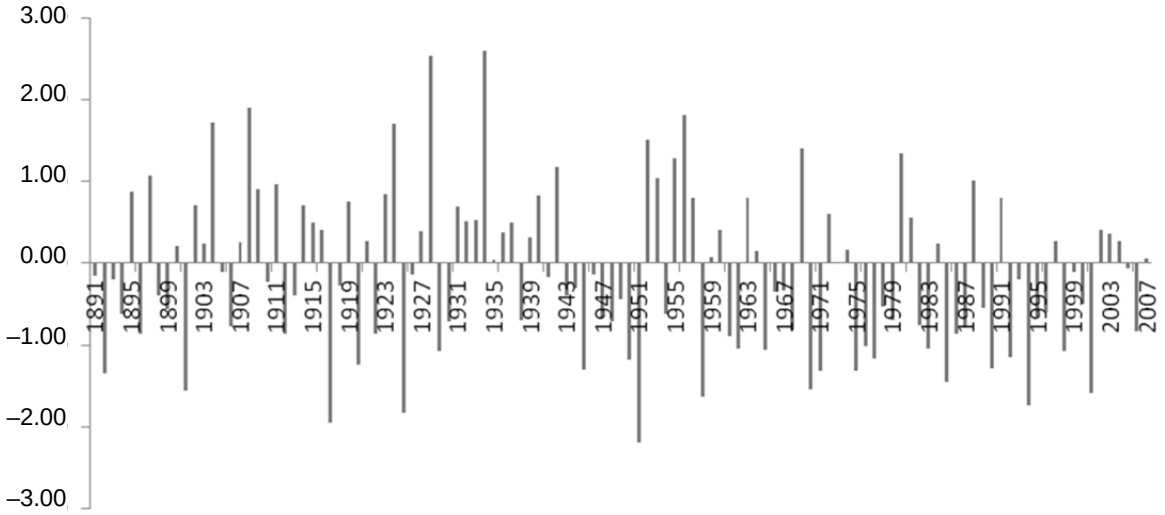

Fig. 1. The course of the *SPI* values for spring in Lankaran (1891–2007)

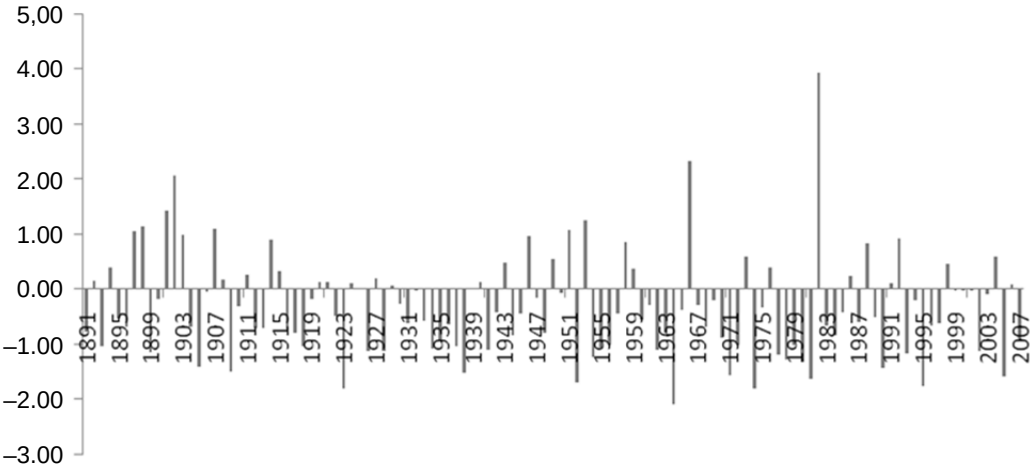

Fig. 2. The course of the *SPI* values for autumn in Lankaran (1891–2007)

of the second period accounted for 32% of all spring droughts.

Twenty eight years between 1891 and 1940, 25 years between 1940 and 1975 and 19 years between 1976 and 2007 were dry in Lankaran. Thirty nine percent out of 72 droughts which happened in autumn occurred in the first global warming period, 35% in the second, 26% in the third. Comparison of autumn and spring droughts shows that the number of autumn droughts is by 9% higher than that of spring droughts.

As seen in Figure 3, the second half of the period 1891–2007 was drier than the first period. Twenty six of the first 53 years, and 34 years of the next period were dry. During the study period in Lankaran, dry years were distributed in the proportion of 26/34. Forty three percent of 60 defined dry years happened in the first half of the period, 57% – in the second half. Noteworthy, droughts of the second period were more severe than those of the first one. Fifteen percent droughts were moderate to severe, 42% were near normal. Moderate and severe droughts constituted only 5% of all droughts, 38% of droughts represented near normal climate conditions of the first part of the study period. So 81% of droughts defined by comparing to the average years were weak, 18% were moderate and severe and 1% was extreme drought.

Rivers are known to indicate humidity conditions of the territory: river flow decreases, small rivers become dry. The influence of meteorological drought on different characteristics of river flow were analysed based on data from 1971.

As seen in the table, observed flow characteristics of 4 rivers in the Lankaran region were considerably smaller than the average long term values. Analysis of regional stations' information shows that annual precipitation was by 27% smaller less than the mean long term value. Some little rivers of the region (the Matala, Goytepe, Boykandul, Shinapadere rivers) became dry. One of the reasons of droughts in 1971 was that the 1970's were dry in general.

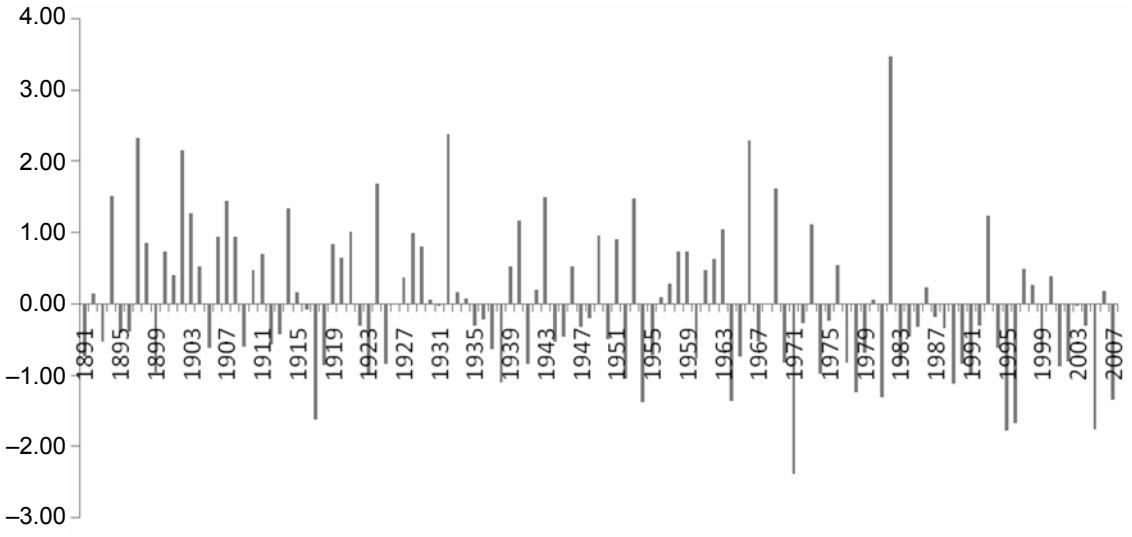

Fig. 3. The course of annual values of the *SPI* in Lankaran

Table 5. The influence of meteorological droughts on river flow in the Lankaran Province (1971)

River – station	Annual flow		Minimum summer flow		Minimum winter flow		Maximum flow	
	K	*R*,%	*K*	*R*,%	*K*	*R*,%	*K*	*R*,%
Lankaranriver – Sifidor	0.75	78.1	1.02	36.7	0.32	98.3	0.32	98.3
Vasharu – Dashtatuk	0.77	64.4	0.86	44.8	1.30	21.1	0.27	92.7
İstisuriver – Alasha	0.39	92.6	0.68	70.9	0.21	96.4	0.12	96.3
Tengerud – Vago	0.42	97.0	0.37	93.1	0.13	98.0	0.17	97.2
$\bar{K}$	0.66	–	0.64	–	0.70	–	0.77	–

According to some studies, mean annual water use of the Lankaran rivers is supposed to increase two times within the next 5–6 years due to global warming.

Drought is accompanied not only by water deficits and worse ecological situation but also by food shortages. Therefore, drought is a socio-economic problem. The study of this natural process demands complex approach and deep scientific investigation. Only by this way it is possible to prepare complex measures to reduce negative effects of droughts on the country economy and environment.

CONCLUSION

The standardized precipitation index (*SPI*) method was used to study droughts. The Lankaran region was chosen as the study area. Analysis of rainfall data from 1891–2007 showed that the number of droughts in the second half of the period was approximately by 14% higher than the number of droughts determined in the first half of the period. Moreover, the droughts of the second half were more severe than those of the first half. The reason for this was probably associated with a reduction by 5–8% of precipitation in the last years. The effect of droughts on waters of the Lankaran rivers was estimated. According to forecast, the increase of droughts in the last 5–6 years will result in doubling water use of the Lankaran rivers and in water deficits.

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Badania suszy w regionie Lankaran w Azerbejdżanie

STRESZCZENIE

Słowa kluczowe: *Lankaran, przepływ wody w rzece, standaryzowany wskaźnik opadu, strefa klimatyczna, susza*

Badania suszy jako elementu Światowego Programu Żywnościowego mieszczą się w obszarze naszych zainteresowań badawczych. Niniejszy artykuł przedstawia wyniki badań nad suszą w jednym z najważniejszych gospodarczo obszarów Azerbejdżanu. Istnieją różne metody analizowania suszy. Ponieważ wybrany region charakteryzuje się znacznymi opadami, do badań wybrano metodę standaryzowanego wskaźnika opadu (*SPI*). Lata suche wyznaczono według sezonowych i rocznych danych, pozyskanych ze stacji meteorologicznych regionu.

Analiza opadów z lat 1891–2007 wykazała, że liczba susz w drugiej połowie tego okresu była około 14% większa niż w pierwszej. Co więcej, susze w drugiej połowie były znacznie głębsze i dotkliwsze dla rolnictwa. Wynika to m.in. z faktu, że opady zmniejszyły się o 5–8%. Analizy wykazują, że w ostatnich 5–6 latach dwukrotnie zwiększył się pobór wody w zlewni rzek Lankaran i stale zwiększa się deficyt wody.

Susze powodują straty ekologiczne i przyczyniają się do występujących okresowo braków żywności. Jest to więc istotny problem nie tylko przyrodniczy, ale też socjalno-ekonomiczny.