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DROUGHTS AND THEIR IMPACT ON THE ALBANIAN TERRITORY

SUMMARY

Rainfall anomaly and the Standard Precipitation Index (SPI) are the most common meteorological drought indices. The most used and simplest index in the meteorological literature is the SPI.

Agriculture is usually the first economic sector to be affected by drought. Agricultural drought can be monitored by focusing on precipitation shortages, differences between ET_a and ET_0, soil water deficits and reduced ground water and/or reservoir levels. Hydrological drought is associated with the effect of periods of precipitation shortfalls on surface or subsurface water supply. The frequency and severity of hydrological drought is often defined on a watershed basin scale. Although climate is a primary contributor to hydrological drought, other factors such as changes in land use, land degradation, and the construction of dams all affect the hydrological characteristics of a basin.

The climate change scenario for Albania indicates a decrease in the amount of precipitation by about 12.5% up to the year 2100. Consequently, severe and extremely dry conditions will have a tendency to increase.

The aim of this paper is to present an overview of the agricultural drought indices in current use in Albania, considering the meteorological, climatological, hydrological and agrometeorological elements provided by the IGEWE (a partner in the regional project DMCSEE). Drought is a frequent and common climate phenomenon that happens in almost all climate zones, with impacts in socio-economical areas such as agriculture, energy, etc.

Key words: Climatological drought, Hydrological drought, Agriculture drought, SPI index, climate change scenario

INTRODUCTION

Drought is a normal, recurring feature of climate; it occurs in virtually all climatic regimes. It is a temporary aberration, in contrast to aridity, which is a permanent feature of climate and is restricted to low rainfall areas. The

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agricultural sector would be a primary beneficiary of improved drought monitoring, early warning, and decision support tools that would reduce the impacts of drought on society and the environment.

Drought is the consequence of a natural reduction in the amount of precipitation received over an extended period of time, usually a season or more in length. Other climatic factors such as high temperatures, high winds, and low relative humidity are often associated with drought in many regions of the world and can significantly aggravate the severity of the event. This natural reduction in precipitation may lead to a situation where supply is insufficient to meet the demands of human activities and the environment. The result is a series of cascading impacts in a wide range of economic sectors and the environment. Drought is also related to the timing (i.e. principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness of the rains (i.e. rainfall intensity, number of rainfall events). Thus, each drought episode is unique in its climatic characteristics.

In recent decades, drought has had a major impact on the economy of all countries in the South-Eastern European (SEE) region, as well as on the environment and society in general. From the early 80s, some of the countries and regions in the SEE experienced increasingly severe and long-lasting droughts, culminating in record-breaking droughts in '93, '94, '98 and '03.

Many indices of drought are in widespread use today, such as the deciles approach (Gibbs and Maher 1967) used in Australia and the Palmer Drought Severity Index and Crop Moisture Index (Palmer, 1968) used in the United States. A relatively new index that has gained considerable popularity worldwide is the Standardized Precipitation Index (SPI), developed by McKee et al. (1993, 1995). The SPI has undergone rigorous statistical testing (Guttman 1998, Wu et al. 2001, Morid et al. 2006) and it is effective in detecting the early emergence of drought because it can be calculated for multiple time scales. This characteristic lends itself well to the initiation of mitigation actions to reduce drought impacts. Several international organizations (International Commission on Irrigation and Drainage, UN Convention to Combat Desertification and World Meteorological Organization) have participated in shaping a proposal to establish the Drought Management Centre for Southeastern Europe (DMCSEE). The IEWE (now IGEWE) is a partner in the regional project where the SPI index will be in operation in whole SEE region.

Drought in Albania is an event with adverse impact on the environment, economy, agriculture, energy, social life etc. Meteorological drought events have occurred during diverse periods in the Albanian territory.

Droughts are generally classified into three categories: meteorological, hydrological and agricultural droughts. Based on time of occurrence, they are also classified into three categories: permanent, seasonal and contingent drought. Based on medium, there are soil and atmospheric droughts.

MATERIAL AND METHODS

Climate Regime of the Study Area

Albania is situated in the west of Balkan Peninsula, which covers an area of 28.745km^2. Its terrain is mostly mountainous areas, where 77 % consists of mountains and hills with an average altitude of 708 m (INSTAT, 2006). The population is approximately 3.12 million, where urban dwellers account for 45 % of the total and 55% live in rural areas, with overall density of population 166 km^2. The main economic sectors are agriculture, which accounts for 52% of the total share of economy, industry that accounts for 13%, and other services that make up 35% (Figure 1).

Albania is situated in the Mediterranean climatic belt, which is characterized by dry and hot summer and mild winter with abundant rainfall. The value of temperature varies from 7°C on the highest zone (north of Albania) to 15°C in the coastal zone (Archives of the IGEWE).

The climate is warmer in the southern part, relatively dry and is characterized by hot summer with an average temperature of 26°C. Winters are mild and wet, with an average temperature of 9.8°C. In the central and northern part of the country, the average temperature is 23-24°C in the summer and 3-4 °C in the winter. The mean annual precipitation, total over Albania, is 1.485mm/year. The highest values of precipitation are during the period (October–November) and the lowest values during (July–August). The number of rainy days per year varies from 80-120 days/year (Group of Authors 1988).The southern part has a small amount of rainfall where the values reach up to 600–1000 mm/year. The highest values are observed in the northern part, where precipitation is approximately 2800–3000 mm/year. The trend in temperature indicates an increase from 0.6°C in the north (Shkodra) and 0.4°C in south. This trend is observed also in the precipitation, which has mainly decreased during the summer (Figure 1).

Drought Chronology and its impact

Various studies and publications in scientific journals show evidence for chronology of droughts with historical records and their impact in different fields of the economy, particularly in agriculture.

In this paper, the meteorological data bank archives of the IGEWE, are used to trace the chronology and the history of drought according to various studies and projects conducted in Albania as follows:

From 1920 until 1930, the identification of the phenomenon of drought is made press time. After this period and especially after the year 1950, this phenomenon is evidenced by various scientific studies of the Hydrometeorological Institute (Archives of IGEWE). This period is worth mentioning (Group Authors 1988).

The spring drought in 1952 lasted two-and-a-half months. The spring drought in 1953 lasted one-and-a-half months. The summer drought of 1961 lasted almost 4 months. The summer drought of 1965 was almost 5 months; the 1975 drought lasted about 94 days; the 1978 drought about 100 successive days without precipitation, 1985 about 83 successive days without precipitation and 1986 about 80 successive days without precipitation. Because of the drought in 1989–1991, the Albanian economy lost 24 million USD. The November 2003 energy crisis was due to drought. In 2006–2007, 352 fires burned forests and a natural park throughout Albania. On 19/01/2007, drought caused electricity interruptions and on 30/10/2007, drought decreased 33% of average production of Fierza HPP.

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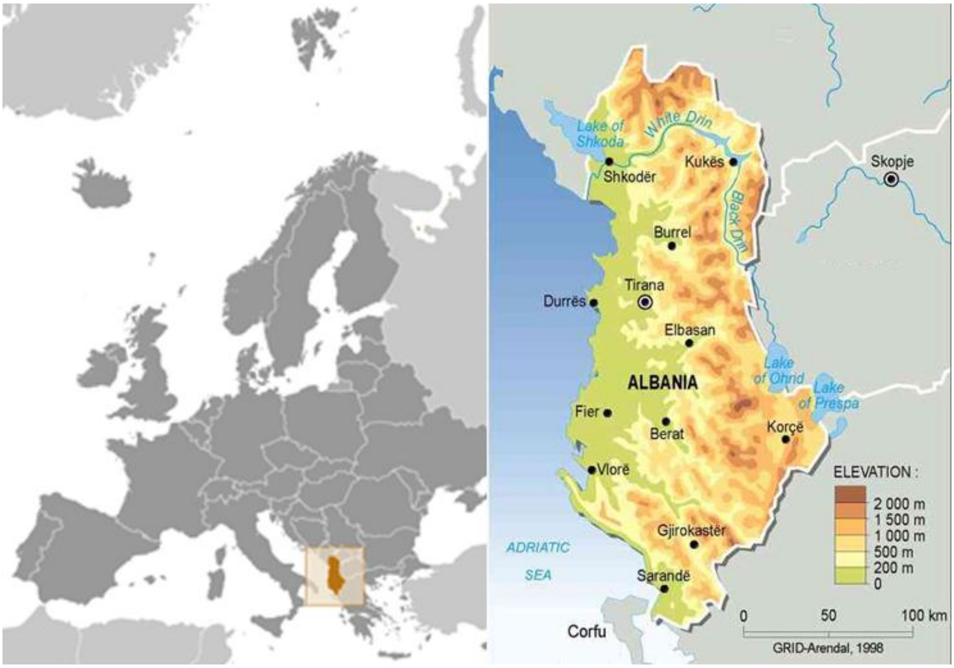

Figure 1: Map of Albania

Drought Indices

In the search for drought indicators, the Standard Precipitation Index (SPI) was evaluated in this paper.

The understanding that a deficit in precipitation has different impacts on groundwater, reservoir storage, soil moisture, snow pack, and stream flow led McKee, Doesken, and Kleist to develop the Standardized Precipitation Index (SPI) in 1993. The SPI was designed to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources (Sevruk and Geiger 1981). Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, stream flow, and reservoir storage reflect the longer-term precipitation anomalies.

Figure 2. The fire due to drought in 2003

Figure 2. Shortage of water in an irrigation channel in 2007

For these reasons, McKee et al. (1993) originally calculated the SPI for 3, 6, 12, 24, and 48 month time scales. The classification system shown in the SPI values table defines drought intensities resulting from the SPI. It also defines the criteria for a drought event for any of the time scales. A drought event occurs any time the SPI is continuously negative and reaches an intensity of –1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that the event continues. The positive sum of the SPI for all months within a drought event can be termed the drought's "magnitude".

The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee 1997). Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way, and wet periods can be monitored using the SPI.

Based on an analysis of stations across Colorado, McKee determined that the SPI is in mild drought 24% of the time, in moderate drought 9.2% of the time, in severe drought 4.4% of the time, and in extreme drought 2.3% of the time (McKee et al. 1993) (Table 1). Because the SPI is standardized, these percentages are expected from a normal distribution of the SPI. The 2.3% of SPI values within the "Extreme Drought" category represent a percentage that is typically expected for an "extreme" event (Wilhite 1995). In contrast, the Palmer Index reaches its "extreme" category more than 10% of the time across portions of the central Great Plains. This standardization allows the SPI to determine the rarity of a current drought, as well as the probability of the precipitation necessary to end the current drought (McKee et al. 1993). The SPI has been used operationally to monitor conditions across Colorado since 1994 (McKee et al. 1995). Monthly maps of the SPI for Colorado can be found on the Colorado State University website (http://ulysses.atmos.colostate.edu/SPI.html). It is also being monitored at the climate division level for the contiguous United States by the National Drought Mitigation Center and the Western Regional Climate Center (WRCC).

Table 1: Drought classification by SPI value and corresponding event probabilities

SPI value	Classification	Cumulative probability (%)
2.00 or more	Extremely wet	2.3
1.50 do 1.99	Very wet	0.4
1.00 do 1.49	Moderately wet	9.2
0 do 0.99	Mildly wet	34.1
0 do -0.99	Mild drought	34.1
-1 do -1.49	Moderate drought	9.2
-1.50 do -1.99	Severe drought	4.4
-2.00 or less	Extreme drought	2.3

RESULTS AND DISCUSSION

Drought is a protracted period of deficient precipitation resulting in extensive damage to crops and loss of yield. The SPI is based only on rainfall data but can be used to monitor drought conditions on a variety of time scales, which makes it useful to describe drought conditions in meteorological, agricultural and hydrological applications. Temporal changeability makes it possible to determine drought dynamics, such as drought onset, duration and end. The next advantage comes from its standardization, which ensures that the frequency of extreme drought events at any location and any time scale are consistent.

A drought event occurs at any time the SPI is continuously negative and reaches an intensity of –1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, as well as an intensity for each month that the event continues (Muçaj et al. 2011). Table 1 shows the SPI values and drought classification (according to cumulative probability). The SPI is the most used and simplest index in the meteorological literature and is based on statistical techniques, which can quantify the degree of wetness by comparing usually one, three, six, 12 or even (sometimes) 24 month rainfall totals with the historical rainfall period.

The one month SPI can be related closely to soil moisture and the three month SPI related to overall crop yield and stream flow conditions of small rivers, while the six and nine month SPI can usually be tied to larger stream flows, reservoir levels, and even groundwater levels.

Definitions of drought include consecutive days without rain (number of days ≤1.0mm). The definition of Hot and Dry Winds are wind speed ≥ 3 m/sec, air temperature ≥25°Cand relative humidity ≤ 30%. According to the DMCSEE project, the SPI index is used to evaluate severity of drought in this target zone. The SPI values for 1 month (SPI 1) are presented in Table 2, based on the drought classification by SPI value for Lezha city.

Table 2. Monthly calculation SPI 1

Classif.	Extremely wet	Very wet	Moderate wet	Near normal	Moderate dry	Severe dry	Extremely dry
SPI value	> +2	1.99-1.5	1-1.49	0.99-0.99	-1 - 1.49	-1.5 - 1.99	< -2
SPI values %	2.6	4.9	9.8	69.0	6.9	3.3	3.3

As Table 2 shows, 69% of the cases are near normal, 6.9% are moderately dry, 3.3% are severely dry and 3.3% are extremely dry. The concurrency of cases with SPI 3 <-1 (moderate, severe and extremely dry) for every decade is shown in Table 3. Regarding the SPI 3 (for a three-month period), the cases of moderate, severe and extreme dryness is calculated for every 10 years. These SPI values calculated for the Lezha station point out that the period from 1981–1990 had the maximum cases of drought, followed by the last period from 2001–2008. Cases of drought have shown a slightly increasing tendency during the last years.

Table 3. The cases of SPI 3

Periods	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2008
Cases	18	7	11	23	19	20

Figure 1 shows the 3-month SPI index for the period from 1951–2008. The figure clearly shows the meteorological drought based on the SPI classification index (Muçaj et al. 2010) pointed out in Table 2.

Almost 16 years show extreme dryness: 1952, 1953, 1955, 1956, 1958, 1969, 1975, 1982, 1985, 1986, 1989, 1990, 1992, 2000, 2003 and 2007.

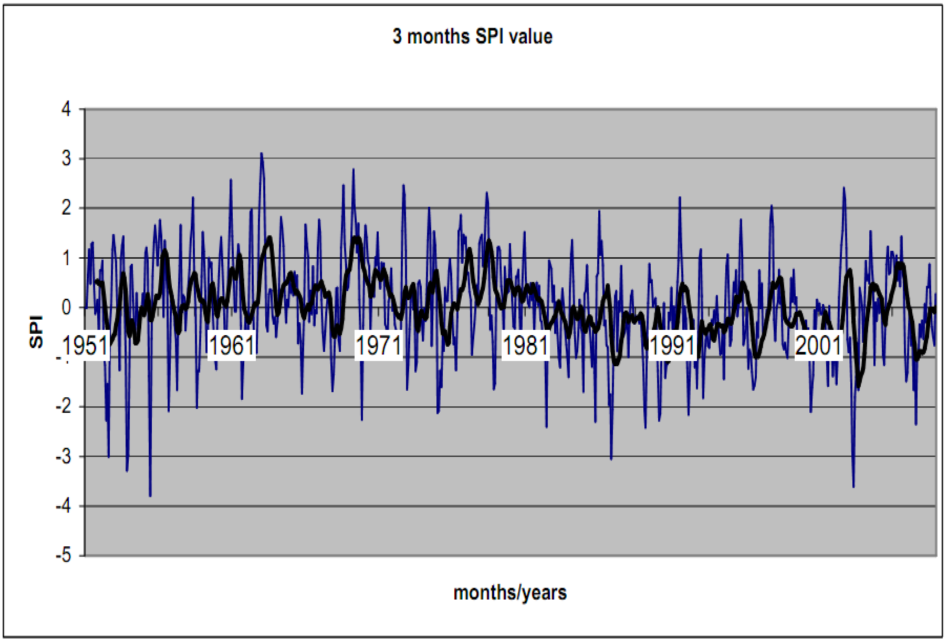

Figure 4. The 3-month SPI for the period 1951–2008

Cases with drought based on a climate change scenario

Because of the good relationship between drought events and precipitation, an increasing occurrence of severe drought is expected. In particular, by the time horizon of 2025, an increase of two cases of severe drought per decade is expected; by the time horizon of 2050, an increase of five cases per decade is expected, and this increases to nine cases per decade by the time horizon of 2100.

Figure 4 shows the soil affected by drought and erosion for the Albanian territory.

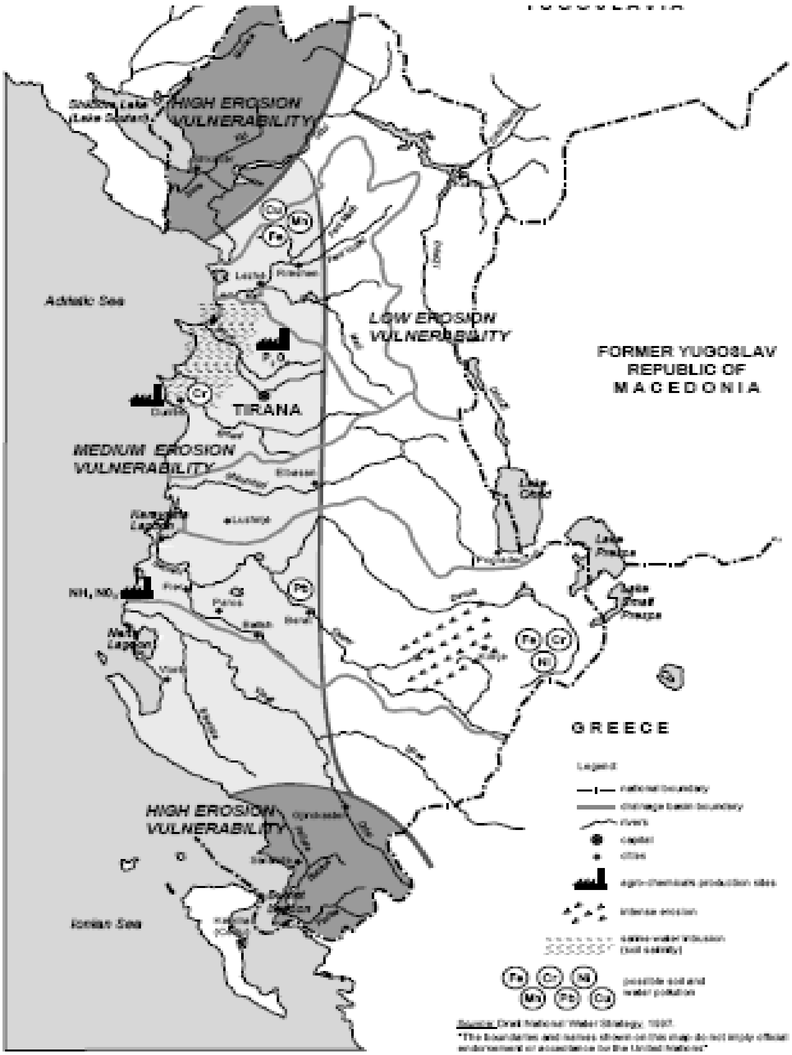

Figure 5. Soil affected by drought and erosion

CONCLUSIONS

The drought indexes used in the early studies mentioned here do not give a general view of drought in this territory. Therefore, the new drought indexes, such as the Palmer drought severity index (PDSI), SPI, etc. should be applied. Albania shows numerous cases of drought phenomena and their impacts are considerable, especially in the agriculture field. Based on SPI 3, the years with extreme dryness were 1952, 1953, 1955, 1956, 1958, 1969, 1975, 1982, 1985, 1986, 1989, 1990, 1992, 2000, 2003, 2007. Cases with drought show a slightly increasing tendency over the last few years.

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SUŠA I NJEN UTICAJ NA TERITORIJI ALBANIJE

SAŽETAK

Indeks meteorološke suše, nedostatak kiše i Standardni indeks padavina (SPI) su najzastupljeniji. Da bi definisali meteorološku sušu postoje neki indeksi. Najčešće upotrebljavan i najjednostavniji u meteorološkoj literaturi je Standardizovani indeks padavina (SPI indeks). Poljoprivreda je obično prvi ekonomski sektor na koji utiče suša. Za nadgledanje poljoprivredne suše, fokusirajući se na nedostatke padavina, razlike između ET_a i ET_0, deficita vode u zemlji, snizili su nivo vode u zemlji i/ili rezervoarima.

Hidrološka suša, uključuje efekte perioda nedostatka padavina na površinu ili potpovršinsko snabdijevanje vodom. Učestalost i jačina hidrološke suše se često definiše na skali razvođa bazena. Iako je klima primarni pomoćnik hidrološkoj suši, drugi faktori kao što su promjene u upotrebi zemlje, degradacija zemlje i izgradnja brana utiču na hidrološke karakteristike bazena.

Scenario promjene klime za Albaniiju vodi smanjenju količina padavina za oko 12.5% do 2100. godine, a kao posljedica se može očekivati da ozbiljni i ekstremno suvi slučajevi imaju tendenciju rasta.

Cilj ovog rada je dati pregled indeksa poljoprivredne suše i Albaniji, razmatrajući meteorološke, klimatske, hidrološke i agrometeorološke elemente koje je obezbijedio IGEWE (partner u regionalnom projektu DMCSEE). Suša je čest i uobičajen klimatski fenomen. Dešava se u skoro svim klimatskim zonama, sa akcentom na socio ekonomski dio, kao kod: poljoprivrede, energije i tako dalje.

Ključne riječi: Klimatska suša, Hidrološka suša, Poljoprivredna suša, SPI indeks, scenario klimatskih promjena